THE OSAGE-LAYTON SANDSTONE AND THE "TRUE" LAYTON SANDSTONE, SOUTHERN PAYNE COUNTY, NORTHERN LINCOLN COUNTY, OKLAHOMA

By

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PAYNE COUNTY, NORTHERN LINCOLN
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CHAPTER I

INTRODUCTION

Location of the Study Area

The study area includes approximately 324 sq. mi. in portions of southern Payne and northern Lincoln Counties, Oklahoma (Figure 1).

Statement of the Problem

At some localities in the study area, the Osage-Layton and "True" Layton sandstones (Figure 2) are productive oil and gas reservoirs. Primary objectives of the investigation were to describe the distributions and structural geology of the two sandstones, and to explain conditions of entrapment of petroleum in the Osage-Layton and True Layton. Secondary objectives were to determine the stratigraphic framework, and composition of the two sandstones.

Previous Investigations

Thickness and lithofacies of the Virgilian and Missourian Series in north-central Oklahoma were documented by Fambrough (1963). Subsurface geology of parts of Lincoln and Payne Counties were studied by Graves (1955). Surface

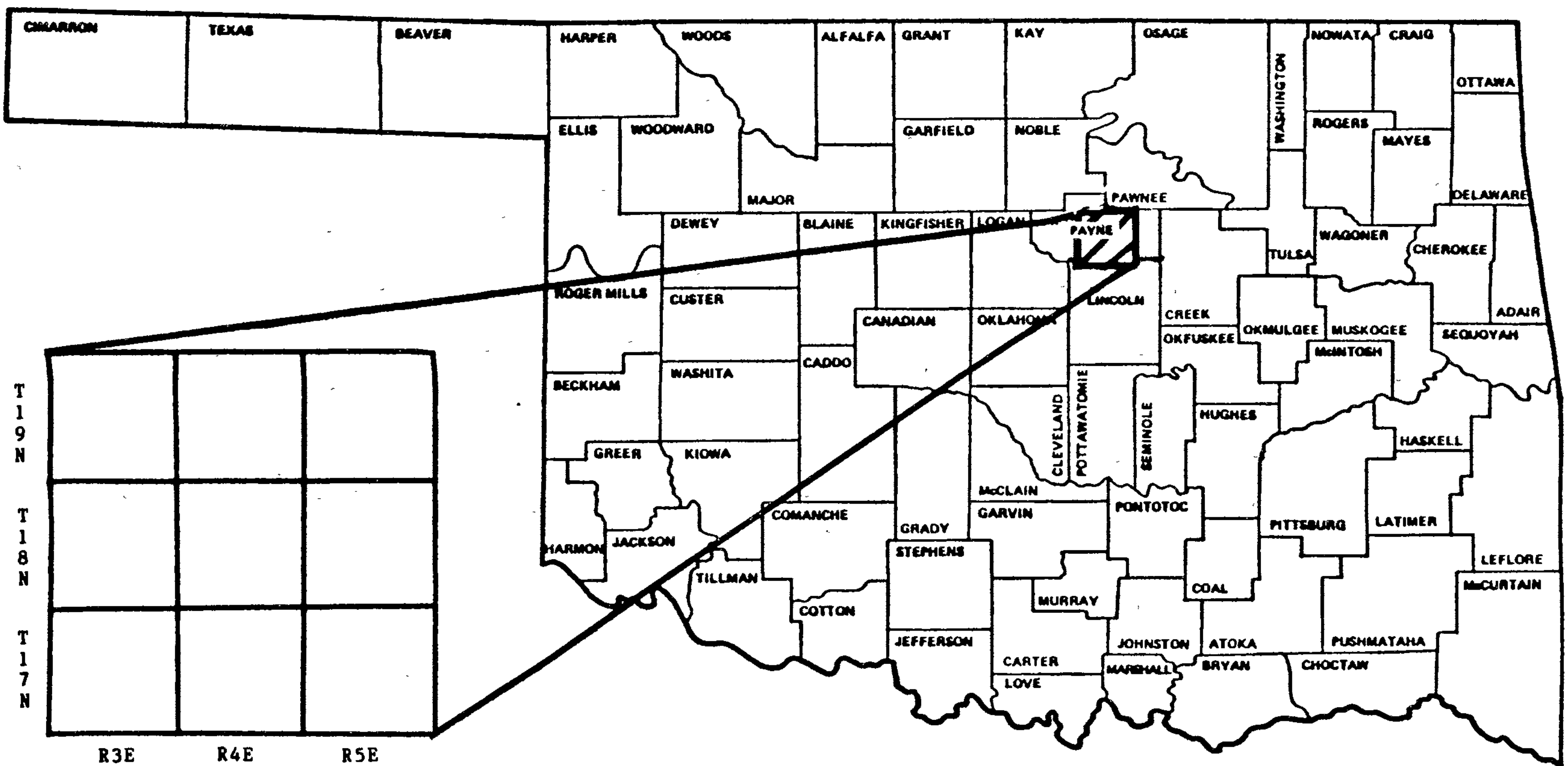

Figure 1. Location of Study Area

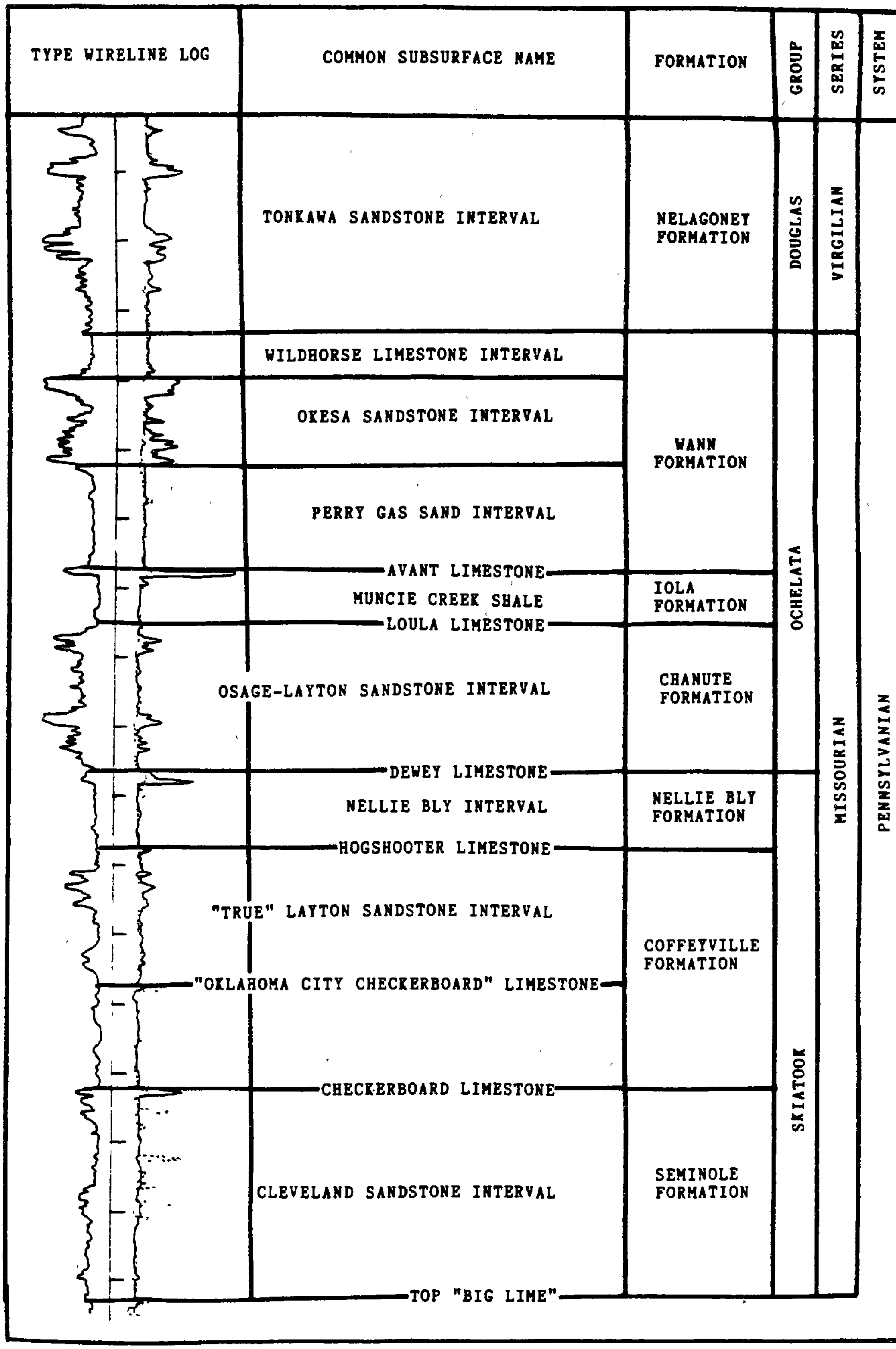

Figure 2. Type Wireline Log (composed from three wells listed in Appendix A).

and subsurface geology and mineral resources of Payne County, Oklahoma were mapped and discussed by Shelton and others (1985).

"True" Layton Sandstones

In research concerning the stratigraphic interval between the Hogshooter Limestone and the Checkerboard Limestone of north-central Oklahoma (Figure 2), Ekebafe (1973) concluded that the True Layton sandstone was deposited as a deltaic complex of sediments derived mostly from regions southeast of the study area. An epeiric-sea deltaic model has been proposed for the deposition of the True Layton sandstone in northern Oklahoma (Visher and others, 1975). Bross (1960) stated that the True Layton sandstone occurs as lenticular bodies of rock that vary greatly in thickness and lithology in Logan County, Oklahoma. Bross proposed that the True Layton sandstone may have been deposited in a shallow, unstable sea. Bennison (1985) studied the outcrop of the Skiatook Group (Figure 2) from east-central Oklahoma to eastern Kansas. He concluded that at least seven full cyclothems are in the Skiatook Group. Bennison divided the Coffeyville Formation (Figure 2) into upper, middle, and lower units and proposed that the Coffeyville be elevated to sub-group status.

Osage-Layton Sandstone

According to Lalla (1975), the Osage-Layton sandstone was deposited in a deltaic setting. From an exposure in Washington County, Oklahoma, Oakes (1940) described the Osage-Layton as buff, fine grained, massive to thinly bedded sandstone. Bross (1960) studied the distribution of the Osage-Layton sandstone in Logan County, Oklahoma. He divided the Osage-Layton into two units, which he called the Lower Cottage Grove sand and the Upper Cottage Grove sand. These units are separated by a thin shale. Bross stated that oil production mainly is from the Lower Cottage Grove, which produces from both structural and stratigraphic traps in Logan County. Calvin (1965) described the occurrence of oil and gas in the Cottage Grove Sandstone in southeastern and south-central Kansas, and extreme northern Oklahoma. In essence, Calvin's work suggests that the Osage-Layton sandstone interval changes from a predominantly carbonate-shale sequence in south-central Kansas to a predominant sandstone-shale sequence just north of the Oklahoma state line.

Gibbons (1960) determined that the Osage-Layton sandstone extends westward into Woods County, Oklahoma. He reported that in Woods County, the Osage-Layton sandstone is composed of lenses of sandstone enclosed in siltstone and shale. Rascoe (1978) proposed that Missourian sandstones in central Oklahoma are the record of fluvialdeltaic conditions, but added that equivalent sandstones in western Oklahoma may have formed under marine influences.

In his study of Missourian and early Virgilian stratigraphy in northwestern Oklahoma, Capps (1959) concluded that the Osage-Layton sandstone was deposited on a shallow marine shelf. Holmes (1966) interpreted the Osage-Layton as a series of submarine bars trending northeastward in the Cedardale Field in portions of Woodward and Major Counties, Oklahoma. Towns (1978) described the Osage-Layton sandstone in the South Gage Field, Ellis County, Oklahoma as an offshore shallow-marine bar. Fruit (1986) interpreted the Osage-Layton of northwestern Oklahoma as an open-marine shelf deposit consisting of linear sand ridges encased in shale. Wade (1987) concluded that the Osage-Layton was deposited on an epeiric shallow marine shelf, during transgression, under the influence of storm- and tide-dominated conditions in portions of Dewey, Ellis, and Roger Mills Counties, Oklahoma. (All counties mentioned above are shown in Figure 1).

Methods and Procedures

Data used in the study were obtained mostly from approximately 1200 well logs. Other data utilized in the study were obtained from scout cards, Petroleum Information Company cumulative production reports, bit cuttings from one well, and one core from the True Layton sandstone.

Correlation of the stratigraphic units was established by construction of six stratigraphic cross-sections (Figure 3, and Plates 1-6).

Five structural contour maps show configuration of the stratigraphic interval between the Checkerboard and Loula limestones. In ascending stratigraphic order, these maps are based on elevations of the top of the Checkerboard Limestone (Plate 7), the top of the True Layton sandstone (Plate 8), the top of the Hogshooter Limestone (Plate 9), the top of the Osage-Layton sandstone (Plate 10), and the top of the Loula limestone (Plate 11).

An isopach map of the interval between the top of the Checkerboard Limestone and the top of the Hogshooter Limestone (Plate 12) illustrates the geometry of the True Layton interval. Ten thin sections from a core of the True Layton sandstone were examined to determine the general composition of the True Layton sandstone.

An isopach map of the interval between the top of the Hogshooter Limestone and the top of the Loula limestone (Plate 13) shows geometry of the Osage-Layton interval. Bit cuttings and two thin sections of bit cuttings were examined to determine the general composition of the Osage-Layton sandstone.

Entrapment of petroleum in the Osage-Layton sandstone is explained by a series of maps of the several localities where the Osage-Layton is productive. These maps include a structural contour map of the Loula limestone (Plate 14), a

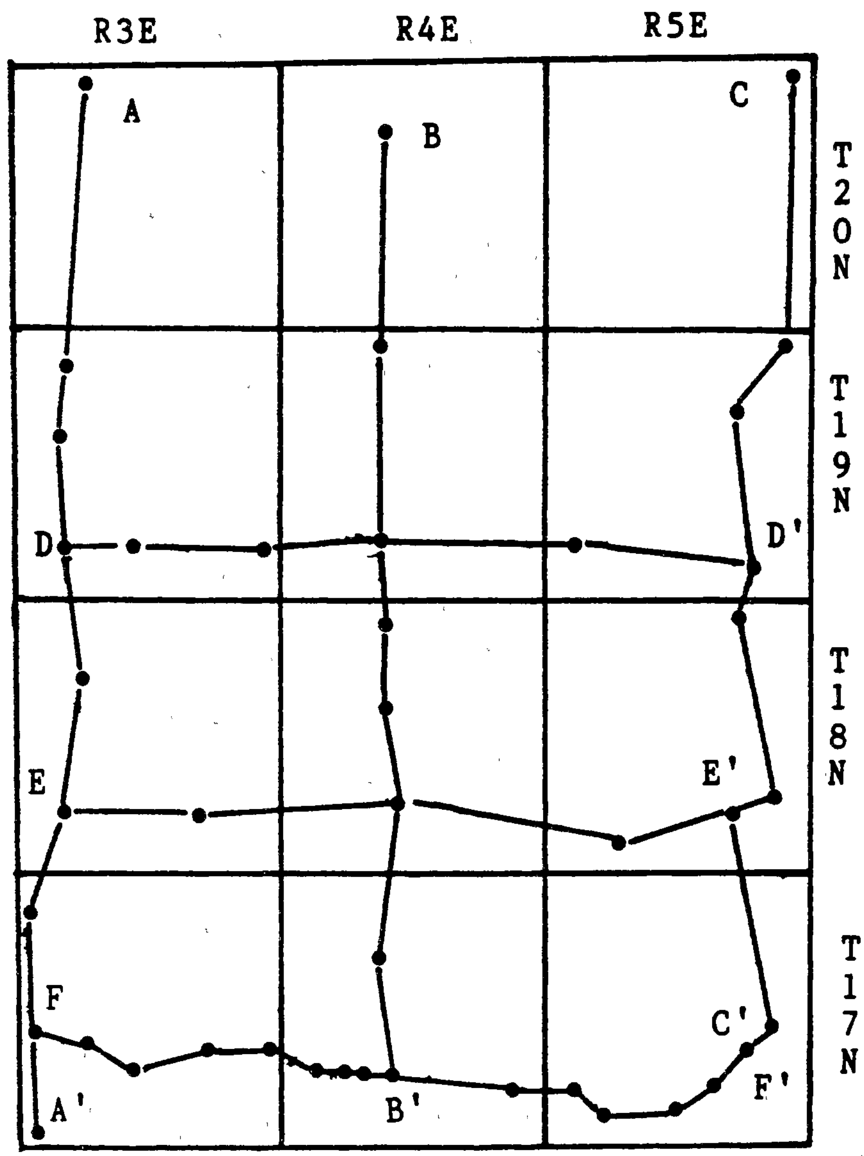

Figure 3. Locations of Regional Strati-
graphic Cross-sections

log-signature map of the Osage-Layton sandstone (Plate 15), and a net-sandstone isopach map of the Osage-Layton (Plate 16), all in the N.E. Mehan field (Figure 4). Plates 17, 18 and 19 illustrate structural geology and distribution of sandstones in Broyles, S. Broyles, March, Cushing Townsite and Norfolk fields. (Locations of fields are shown in Figure 4).

Cumulative production reports published by Petroleum Information Company were used to construct the production decline diagrams of the Osage-Layton and True Layton sandstones.

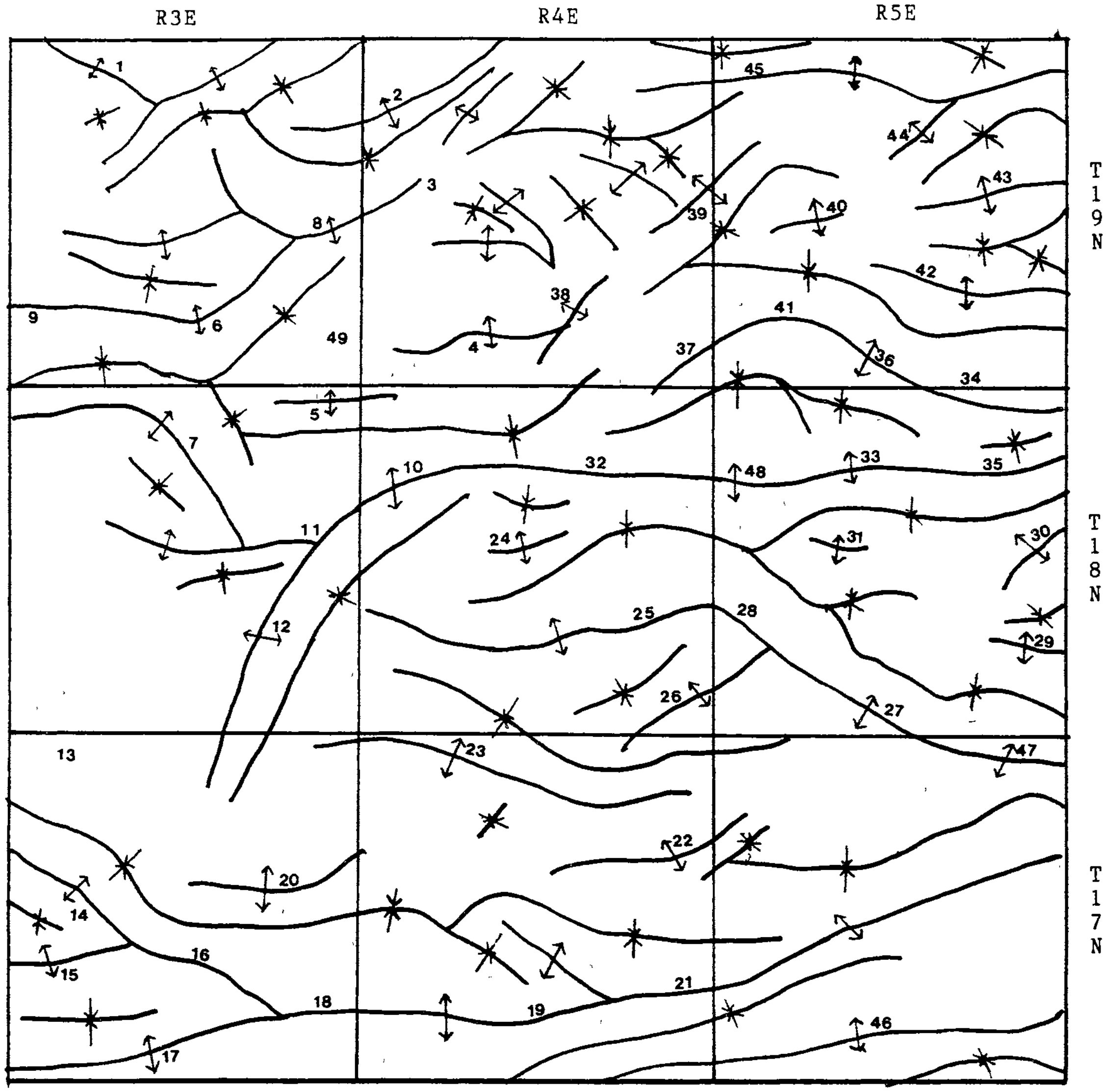

Figure 4. General Trends of Fold-axes, Top of Checkerboard Limestone

<u>Index numbers show general locations of oil fields:</u>
1 - Starr Valley; 2 - Council Creek; 3 - N.W. Ingalls; 4 - W. Ingalls; 5 - High Prairie; 6 - N. Sooner Valley; 7 - N.E. High Prairie; 8 - S.W. Council Creek; 9 - Lost Creek; 10 - N. Ripley; 11 - N.E. Mehan; 12 - Mehan; 13 - E. Perkins; 14 - E. Vinco; 15 - W. Sporn; 16 - Sporn; 17 - S. Sporn; 18 - W. Agra; 19 - N.W. Agra; 20 - S. Cottingham; 21 - N. Agra; 22 - S. Georgia; 23 - Ripley; 24 - N.E. Ripley; 25 - Broyles; 26 - S. Broyles; 27 - Cushing Townsite; 28 - March; 29 - Norfolk; 30 - Norfolk-3; 31 - N.W. Gano; 32 - Long Branch; 33 - W. Norfolk-2; 34 - Norfolk-1; 35 - Norfolk-2; 36 - W. Norfolk-1; 37 - Butcher; 38 - Ingalls; 39 - W. Garr; 40 - S. Garr; 41 - Pratt; 42 - S.W. Yale; 43 - Yale-Quay; 44 - Yale-West; 45 - N. Garr; 46 - Agra; 47 - S. Norfolk; 48 - N. March; 49 - Mt. Hope.

CHAPTER II

STRATIGRAPHIC FRAMEWORK

Missourian Series

The Missourian Series (Figure 2) includes rock-stratigraphic units from the top of the "Big Lime" to the base of the Tonkawa sandstone interval (Bross, 1960). In ascending order the series is divided into the Skiatook and Ochelata Groups. Thickness of the Missourian Series in the study area ranges from about 1500 ft. in the southeast to about 1350 ft. in the northwest as mapped by Fambrough (1962).

Stratigraphic positions of groups, formations, and rock units that bear "subsurface" names and that compose the Missourian Series in the study area are shown on the type log (Figure 2). (The reader will observe that rock-stratigraphic units shown in Figure 2 do not conform with standard rules of stratigraphic nomenclature. Figure 2 was designed to show the order of names used in the normal course of exploration in north-central Oklahoma). The lithologic makeup and relative thickness of stratigraphic units between the Checkerboard Limestone and the top of the Perry gas sand interval are shown on regional cross sections (Plates 1-6).

Skiatook Group

The Skiatook Group includes rock-stratigraphic units from the top of the "Big Lime" to the top of the Dewey Limestone. Where the Dewey is absent the upper contact is defined as the base of the Osage-Layton sandstone (Figure 2). The Skiatook Group is composed of abundant sandstones and shales with a few thin limestones. In ascending order this group includes these commonly mentioned rock-stratigraphic units: Cleveland sandstone, Checkerboard Limestone, "Oklahoma City Checkerboard" limestone, "True" Layton sandstone, Hogshooter Limestone, Nellie Bly Formation, and the Dewey Limestone.

Checkerboard Limestone. The Checkerboard Limestone directly overlies the Cleveland sandstone interval; it is the most reliable marker bed in the study area. The Checkerboard is laterally extensive, 8 to 10 ft. thick, and typically shows high resistivity on wireline logs (Figure 2). The limestone is described by various authors as being off-white, gray to brown, finely crystalline or chalky. The Checkerboard correlates with the Hertha Limestone at the surface (Graves, 1955).

"Oklahoma City Checkerboard" Limestone. The "Oklahoma City Checkerboard" limestone is approximately 70 to 150 ft. above the Checkerboard Limestone (Figure 2). This unit is discontinuous across the study area; in some places it is a series of thinly bedded limestones and shales. Stringer

(1975) described the limestone as brown, compact to chalky, and soft with limestone conglomerates at some localities. The Oklahoma City Checkerboard also has been termed the "lower Hogshooter limestone."

"True" Layton Sandstone Interval. The True Layton sandstone interval is above the Oklahoma City Checkerboard limestone and below the Hogshooter Limestone (Figure 2). The amounts of sandstone and shale in this interval vary a great deal throughout the study area, and some sparse beds of limestone are near the base of the interval (Plates 1-6). The section ranges from 130 to 200 ft. thick, and thickens slightly to the east (Plates 4-6). The True Layton sandstone is off-white to gray, micaceous, calcareous, carbonaceous, subangular to rounded, very fine to medium grained, and is interbedded with dark gray shale. The True Layton sandstone is a member of the Coffeyville Formation (Jordan, 1957), and is correlated with the Dodds Creek Sandstone Member at the surface (Lukert, 1949).

Hogshooter Limestone. The Hogshooter Limestone overlies the True Layton sandstone interval (Figure 2). The marker bed is not as distinctive as the Checkerboard Limestone; however, it is reliable for subsurface correlation. The unit typically shows a low negative spontaneous-potential signature and high resistivity on wireline logs. At some places the Hogshooter is composed of interbedded limestones and shales, making correlation difficult. The

Hogshooter is gray to brown, coarsely crystalline, sandy, oolitic limestone (Bross, 1960).

Nellie Bly Formation. The Nellie Bly Formation overlies the Hogshooter Limestone and underlies the Dewey Limestone. Where the Dewey is absent the upper contact commonly is defined as being the base of the Osage-Layton sandstone (Figure 2). The Nellie Bly consists mostly of shales, with interbedded sandstone at a few places. The shale is gray to dark gray, silty, fissile, micaceous, pyritic, and fossiliferous. The Nellie Bly is correlated with the stratigraphic unit containing the Peoples sandstone of Osage County (Graves, 1955).

Dewey Limestone. The Dewey Limestone is distributed irregularly in the study area. It overlies the Nellie Bly Formation (Figure 2). Where the Dewey is absent its stratigraphic position may be occupied by sandstone of the Osage-Layton (Plates 1-6). In the study area, thickness of the Dewey ranges from 2 to 45 ft. The Dewey shows a poorly developed to well developed spontaneous-potential signature and high resistivity on wireline logs. The Dewey is gray to brown, sandy, very fine to medium grained, crystalline, micaceous, fossiliferous limestone. This rock unit correlates to the Belle City Limestone of central Oklahoma (Graves, 1955 and Wilmarth, 1938).

Ochelata Group

The Ochelata Group includes units from the base of the Osage-Layton sandstone to the base of the Tonkawa sandstone interval, commonly delineated as the top of the Wildhorse Limestone (Figure 2). The group consists of sandstones and shales interbedded with a few thin limestones. As addressed in this study, and in the terminology of classification of rocks in the subsurface, the Ochelata Group is divided in ascending order as follows: Osage-Layton sandstone, Loula limestone, Muncie Creek Shale, Avant Limestone, Perry gas sand, Okesa Sandstone, and the Wildhorse Limestone (Graves, 1955). Strata of the Ochelata Group younger than the Avant Limestone were excluded from the study.

Osage-Layton Sandstone. The Osage-Layton sandstone is within the interval classified at the surface as the Chanute Shale. The stratigraphic interval overlies the Dewey Limestone, but where the Dewey is absent, the sandstone may lie upon the Nellie Bly Formation (Figure 2).

Relative amounts of sandstone and shale in the interval vary markedly throughout the study area. The lower part of the Osage-Layton sandstone grades into shale in the southeastern portion of the study area (Plates 1-6). The sandstone is clear or white to gray, silty to fine grained, micaceous, carbonaceous, pyritic, angular to subangular, and calcareous.

In this study the Osage-Layton sandstone is regarded as being correlated with the Cottage Grove Sandstone Member of the Chanute Shale, and probably also with the Noxie Sandstone Member. The Osage-Layton of the subsurface has been referred to as the Broyles Layton, Lower Tonkawa, Peoples-Layton, Layton, Cottage Grove, and Mussellem sands (Jordan, 1957).

Loula Limestone. The Loula limestone overlies the Osage-Layton sandstone (Figure 2). The marker bed is persistent mostly throughout the study area and on electric logs shows a low spontaneous-potential signature and high resistivity relative to the overlying and underlying beds. The Loula is 2 to 10 ft. thick and in some places is composed of thinly bedded limestones and shales (Plates 1-6). The log characteristics and the lateral consistency of the bed suggest that the Loula may correlate with the Paola Limestone Member at the base of the Iola Limestone of Kansas (Dalton, 1960). The Loula limestone is brownish gray, silty, bioclastic, and coarsely crystalline.

Muncie Creek Shale Member. The Muncie Creek Shale Member of the Iola Formation directly overlies the Loula marker bed and underlies the Avant Limestone (Figure 2); where the Avant is not present the upper contact provisionally is designated as the base of the Perry gas sand. In the study area, thickness of the Muncie Creek ranges from 20 to 80 ft. (Plates 1-6). The Muncie Creek consists predominantly of shale with interbeds of sandstone at some localities. The shale is dark greenish gray, silty, fissile, micaceous, calcareous, and fossiliferous.

Avant Limestone. The Avant Limestone is distributed erratically in the study area. It is 27 to 95 ft. above the Loula marker bed (Figure 2), and ranges in thickness from 3 to 30 ft. (Plates 1-6). The Avant shows a low spontaneous-potential signature and high resistivity on electric logs. The Avant is nonclayey to sandy, white to tan, coarsely crystalline, fine grained, pyritic, and dolomitic.

Perry Gas Sand. The Perry gas sand interval overlies the Avant Limestone and underlies the Okesa sandstone interval (Figure 2). Graves (1955) described the sandstone as off-white to gray, dirty, very fine grained, and carbonaceous. The proportion of sandstone within this interval increases southward (Plates 1-3).

CHAPTER III

STRUCTURAL GEOLOGY

The study area is located in the west-central portion of the northeastern Oklahoma Platform (Figure 5). The northeastern Oklahoma Platform is bounded by the Nemaha Ridge on the west, the Ozark Uplift on the east, the Arkoma Basin on the southeast, and the Arbuckle Uplift on the south (Arbenz, 1956).

Structural contour maps of the tops of the Checkerboard limestone, Hogshooter Limestone, and the Loula Limestone (Plates 7, 9 and 11) show that regional dip is westward at about 65 ft./mi. The structural features on this homocline are plunging anticlinal and synclinal noses, anticlines, and normal faults. The anticlinal and synclinal folds are defined by dips as great as 150 ft./mi.; the normal faults have throws as great as 70 ft.

Three major structural trends are recognizable in the study area: northwest-southeast, northeast-southwest, and east-west (Figures 4, 6 and 7). Trends of structural axes, as shown on maps of the tops of the Checkerboard Limestone (Figure 4), Hogshooter Limestone (Figure 6), and Loula limestone (Figure 7) appear to be offset slightly, especially in the southeastern part of the study area.

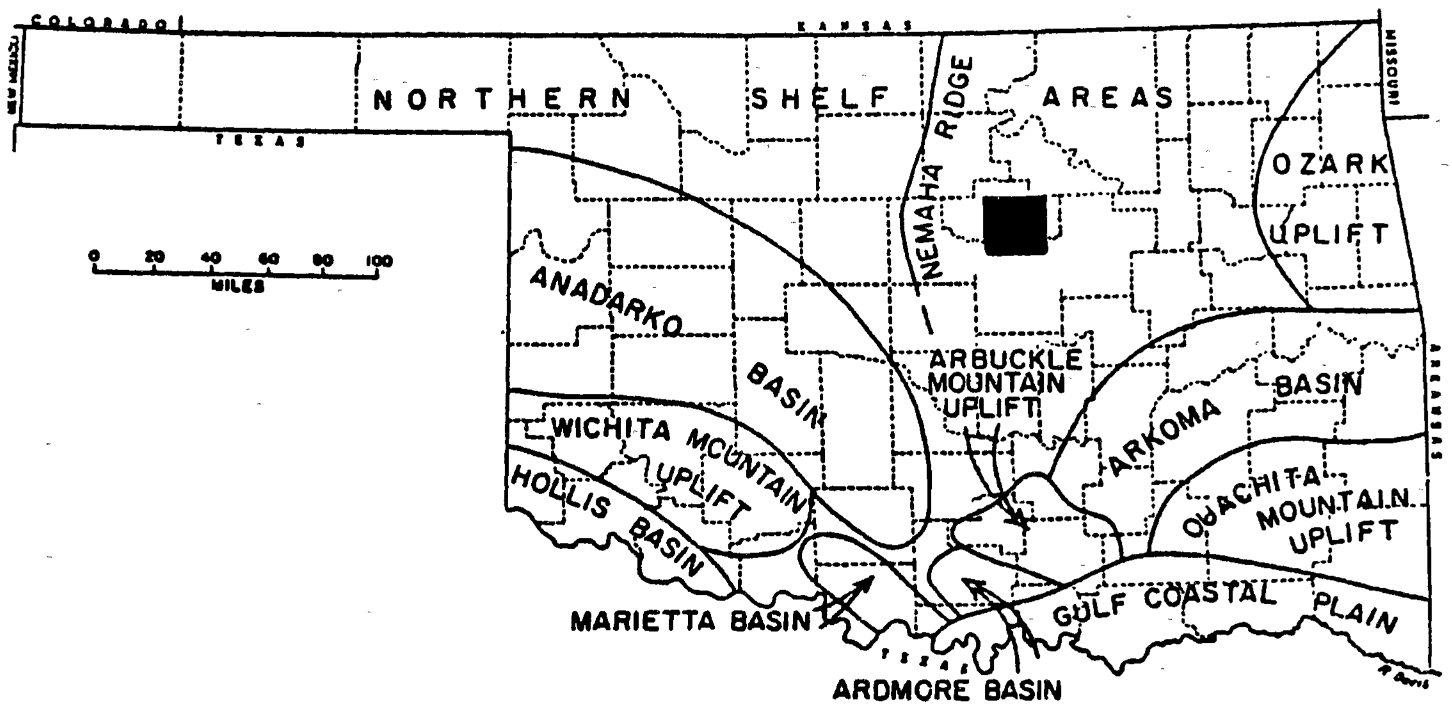

Figure 5. Geological Provinces of Oklahoma (modified from Arbenz, 1956). Study Area Shaded

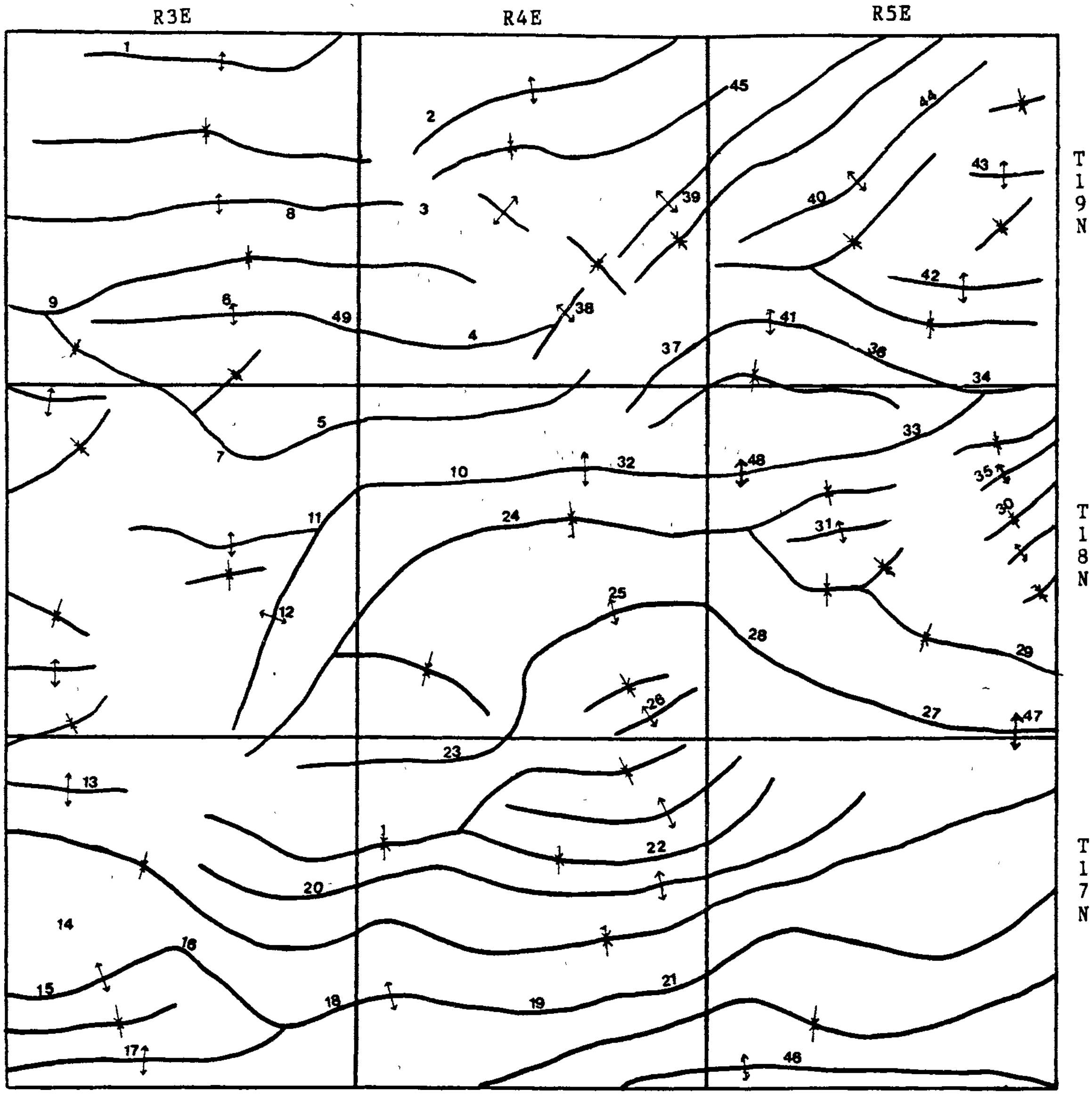

Figure 6. General Trends of Fold-axes, Top of Hogshooter Limestone

<u>Index numbers show general locations of oil fields:</u>
1 - Starr Valley; 2 - Council Creek; 3 - N.W. Ingalls; 4 - W. Ingalls; 5 - High Prairie; 6 - N. Sooner Valley; 7 - N.E. High Prairie; 8 - S.W. Council Creek; 9 - Lost Creek; 10 - N. Ripley; 11 - N. E. Mehan; 12 - Mehan; 13 - E. Perkins; 14 - E. Vinco; 15 - W. Sporn; 16 - Sporn; 17 - S. Sporn; 18 - W. Agra; 19 - N.W. Agra; 20 - S. Cottingham; 21 - N. Agra; 22 - S. Georgia; 23 - Ripley; 24 - N.E. Ripley; 25 - Broyles; 26 - S. Broyles; 27 - Cushing Townsite; 28 - March; 29 - Norfolk; 30 - Norfolk-3; 31 - N.W. Gano; 32 - Long Branch; 33 - W. Norfolk-2; 34 - Norfolk-1; 35 - Norfolk-2; 36 - W. Norfolk-1; 37 - Butcher; 38 - Ingalls; 39 - W. Garr; 40 - S. Garr; 41 - Pratt; 42 - S.W. Yale; 43 - Yale-Quay; 44 - Yale-West; 45 - N. Garr; 46 - Agra; 47 - S. Norfolk; 48 - N. March; 49 - Mt. Hope.

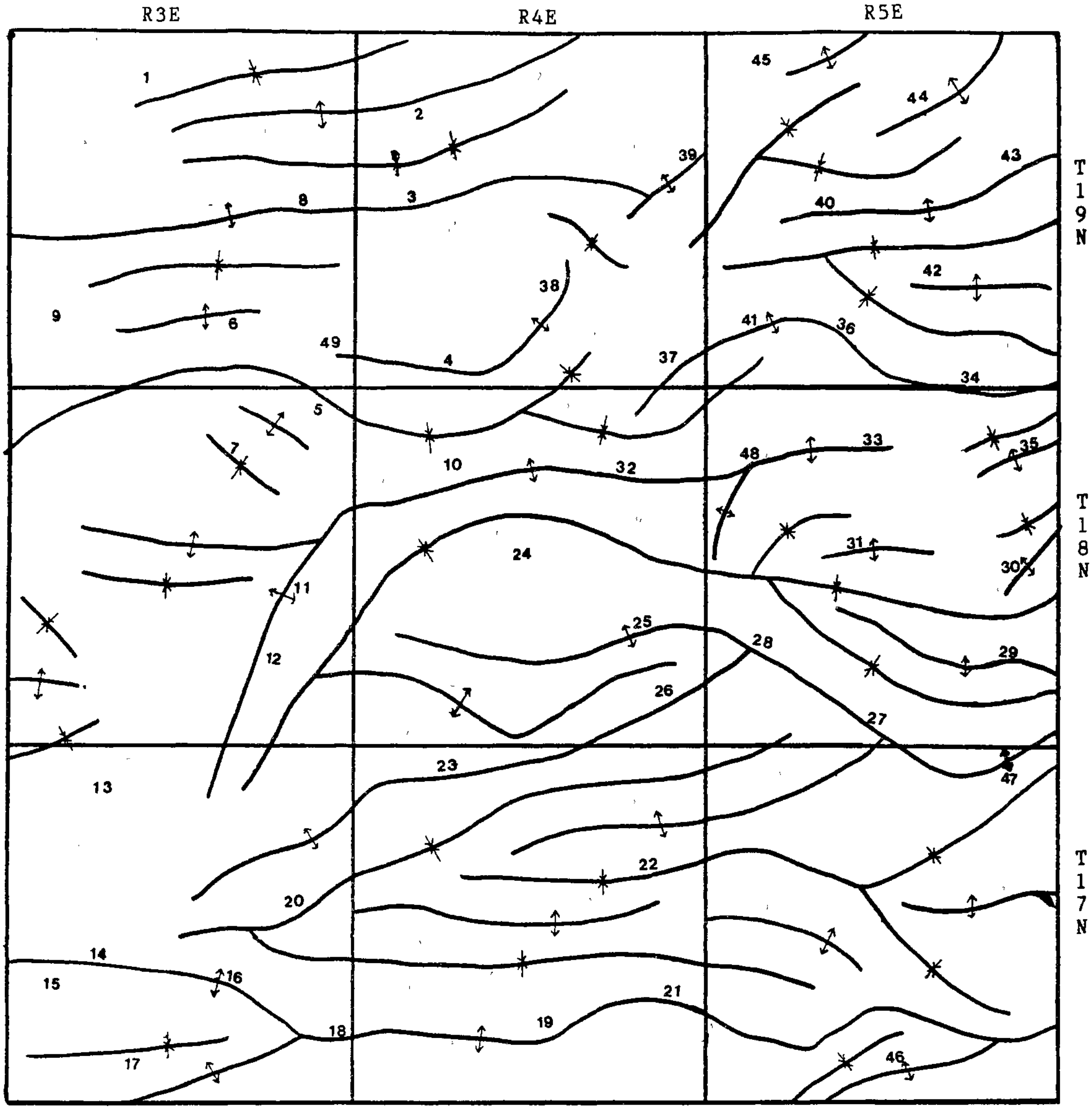

Figure 7. General Trends of Fold-axes, Top of Loula Limestone

<u>Index numbers show general locations of oil fields:</u>
1 - Starr Valley; 2 - Council Creek; 3 - N.W. Ingalls; 4 - W. Ingalls; 5 - High Prairie; 6 - N. Sooner Valley; 7 - N.E. High Prairie; 8 - S.W. Council Creek; 9 - Lost Creek; 10 - N. Ripley; 11 - N. E. Mehan; 12 - Mehan; 13 - E. Perkins; 14 - E. Vinco; 15 - W. Sporn; 16 - Sporn; 17 - S. Sporn; 18 - W. Agra; 19 - N.W. Agra; 20 - S. Cottingham; 21 - N. Agra; 22 - S. Georgia; 23 - Ripley; 24 - N.E. Ripley; 25 - Broyles; 26 - S. Broyles; 27 - Cushing Townsite; 28 - March; 29 - Norfolk; 30 - Norfolk-3; 31 - N.W. Gano; 32 - Long Branch; 33 - W. Norfolk-2; 34 - Norfolk-1; 35 - Norfolk-2; 36 - W. Norfolk-1; 37 - Butcher; 38 - Ingalls; 39 - W. Garr; 40 - S. Garr; 41 - Pratt; 42 - S.W. Yale; 43 - Yale-Quay; 44 - Yale-West; 45 - N. Garr; 46 - Agra; 47 - S. Norfolk; 48 - N. March; 49 - Mt. Hope.

Differential compaction of marker beds over thick, multi-storied linear bodies of sandstone is the most probable explanation for offset of axes upward in the stratigraphic section.

The major northwest-trending feature is a plunging anticlinal nose with closure at the positions of the S. Norfolk, Cushing Townsite, and March fields (Plates 7, 9 and 11). The S. Norfolk field has approximately 60 ft. of structural closure on the Checkerboard and the Hogshooter Limestones; at the position of the Loula limestone an anticlinal nose is present with no structural closure.[1] The Cushing Townsite field has approximately 60 ft. of structural closure on the Checkerboard, Hogshooter, and Loula limestones (Plates 7, 9 and 11).[2] The March field has approximately 55 ft. of structural closure on the Checkerboard, Hogshooter, and Loula. A northwest-trending anticlinal "dome" is present at the position of the Ripley field. This feature has about 75 ft. of structural closure on the Checkerboard, 50 ft. of closure on the Hogshooter, and 40 ft. of closure on the Loula limestone.

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[1]I recognize the limitations on determination of closure. If one contour line is closed and the contour interval is 50 ft., then closure theoretically could be as little as a foot or as much as almost 100 ft. However, I have approximated closure as being the most likely closure that would be present on a fold.

[2]In the following discussion many references are made to structural contour maps of the Checkerboard, Hogshooter and Loula limestones. In each instance, Plates 7, 9 and 11 show useful evidence. To avoid burdensome repetition, citations of the plates are few.

The major northeast-trending anticlinal features are the Ingalls, West Garr, Butcher-Pratt, Mehan, and Norfolk-3 fields. A northeast-trending anticlinal "dome" is present at the position of the Ingalls field. This feature has approximately 80 ft. of structural closure on the Checkerboard Limestone, 65 ft. of closure on the Hogshooter Limestone, and 40 ft. of closure on the Loula limestone. At the position of the Checkerboard limestone (Plate 7), a normal fault on the north side of Ingalls field has approximately 40 ft. of displacement, downthrown to the north. This fault seems not to be present at the stratigraphic positions of the Hogshooter and Loula marker beds (compare Plate 7 with Plates 9 and 11). The West Garr field is characterized by a northeast-trending dome with structural closure of approximately 40 ft. on the Checkerboard, Hogshooter, and Loula limestones (Plates 7, 9, and 11). The High Prairie and Mehan fields are local anticlinal flexures in a larger northeast-trending structural complex. West-trending anticlinal noses underlie the High Prairie and Northeast Mehan fields. A northeast-trending anticlinal dome is located at the position of the Mehan field. This structure has approximately 70 ft. of structural closure on the Checkerboard, Hogshooter, and Loula limestones. A prominent anticlinal nose occurs on the Checkerboard at the position of the Norfolk-3 field (Plate 7). This nose is present on the Hogshooter and Loula limestones, however it is not as prominent (Plates 9 and 11).

Two major east-trending anticlinal features are recognized in the study area. A plunging anticlinal nose is located along the Norfolk-2, West Norfolk-2, North March, Long Branch, and North Ripley fields. Structural closure along this nose is at the positions of the West Norfolk-2, North March, and the North Ripley fields. The anticlinal dome that underlies the West Norfolk-2 field has approximately 40 ft. of structural closure on the Checkerboard, Hogshooter, and Loula limestones. The anticlinal dome at the North March field has about 50 ft. of structural closure on the Checkerboard and Hogshooter Limestones (Plates 7 and 9), and about 60 ft. of closure on the Loula (Plate 11). The anticlinal dome at the North Ripley field has approximately 40 ft. of structural closure on the Checkerboard, Hogshooter, and Loula.

The second major east-trending feature is a plunging anticlinal nose located along the North Agra, Northwest Agra, West Agra, and Sporn fields. No closure was recognized along this trend.

Other anticlinal folds lie along east-wet trends at Starr Valley, Lost Creek, North Sooner Valley, North Ingalls, North Garr, Yale-Quay, South Yale-Quay, Norfolk-1, West Norfolk-1, Northwest Gano, South Georgia, Cottingham, East Vinco, Broyles, and Norfolk fields (Plates 7). An anticlinal dome at the position of the Starr Valley field has approximately 40 ft. of structural closure on the Checkerboard Limestone; on the Hogshooter and Loula limestones this feature is shown as an anticlinal nose. The anticlinal dome located at the Lost Creek field has about 70 ft. of structural closure on the Checkerboard, 60 ft. of closure on the Hogshooter, and 50 ft. of closure on the Loula limestone. The anticlinal dome at North Ingalls field has about 40 ft. of structural closure on the Checkerboard, Hogshooter, and Loula limestones. Axes of folds at Lost Creek and North Ingalls fields seem to migrate northward with depth.

The dome at the North Sooner Valley field has about 60 ft. of structural closure on the Checkerboard, Hogshooter, and Loula. The dome located at Norfolk-1 field has approximately 70 ft. of structural closure on the Checkerboard and Hogshooter limestones and about 40 ft. of closure on the Loula. The anticline at West Norfolk-1 field has about 65 ft. of structural closure on the Checkerboard and 40 ft. of closure on the Hogshooter, but is shown as an anticlinal nose on the Loula. The dome at North March field has approximately 50 ft. of structural closure on the Checkerboard, Hogshooter, and Loula limestones.

As stated previously, the Ingalls field is bounded on the north by a normal fault that penetrates the Checkerboard Limestone. One line of evidence for this fault is the uncommonly steep dip on the north side of the Ingalls flexure. Other faults may be present in the study area at the positions of the Loula, Hogshooter, and Checkerboard limestones; however, due to sparse well control these faults could not be mapped confidently. For example, a normal fault seems to be present in T17N, R5E, in parts of sections 27 and 28 (Plates 7-11). The evidence for the presence of this fault is that 80 ft. of section appear to be missing between the Oklahoma City Checkerboard limestone and the base of the True Layton sandstone (Figure 8). A large syncline on the south side of the Mehan field (Plate 7) seems to be related to faulting in basement rocks.

Shelton and others (1985) mapped structural geology of the shallow subsurface of Payne County. They used three reference surfaces, all of which are younger than the Loula limestone. A normal fault was shown in parts of sections 2 and 3, T17N, R5E, extending northwestward through the southern part of section 34, T18N, R5E. They showed another normal fault located in the northeast part of section 2, T17N, R5E, extending northwestward through the southern part of section 35, T18N, R5E. As mapped, these faults extend for distances of less than 2 mi. Shelton and other (1985) did not describe the evidence that led to interpretation of the above-mentioned faults. If these faults are present at the position of the Lecompton Limestone, then they should also be present at the Checkerboard Limestone, True Layton sandstone, Hogshooter Limestone, Osage Layton sandstone, and the Loula limestone (Plates 7-11).

Hollrah (1977) stated that folding and faulting in Paleozoic strata of western Payne County are related to

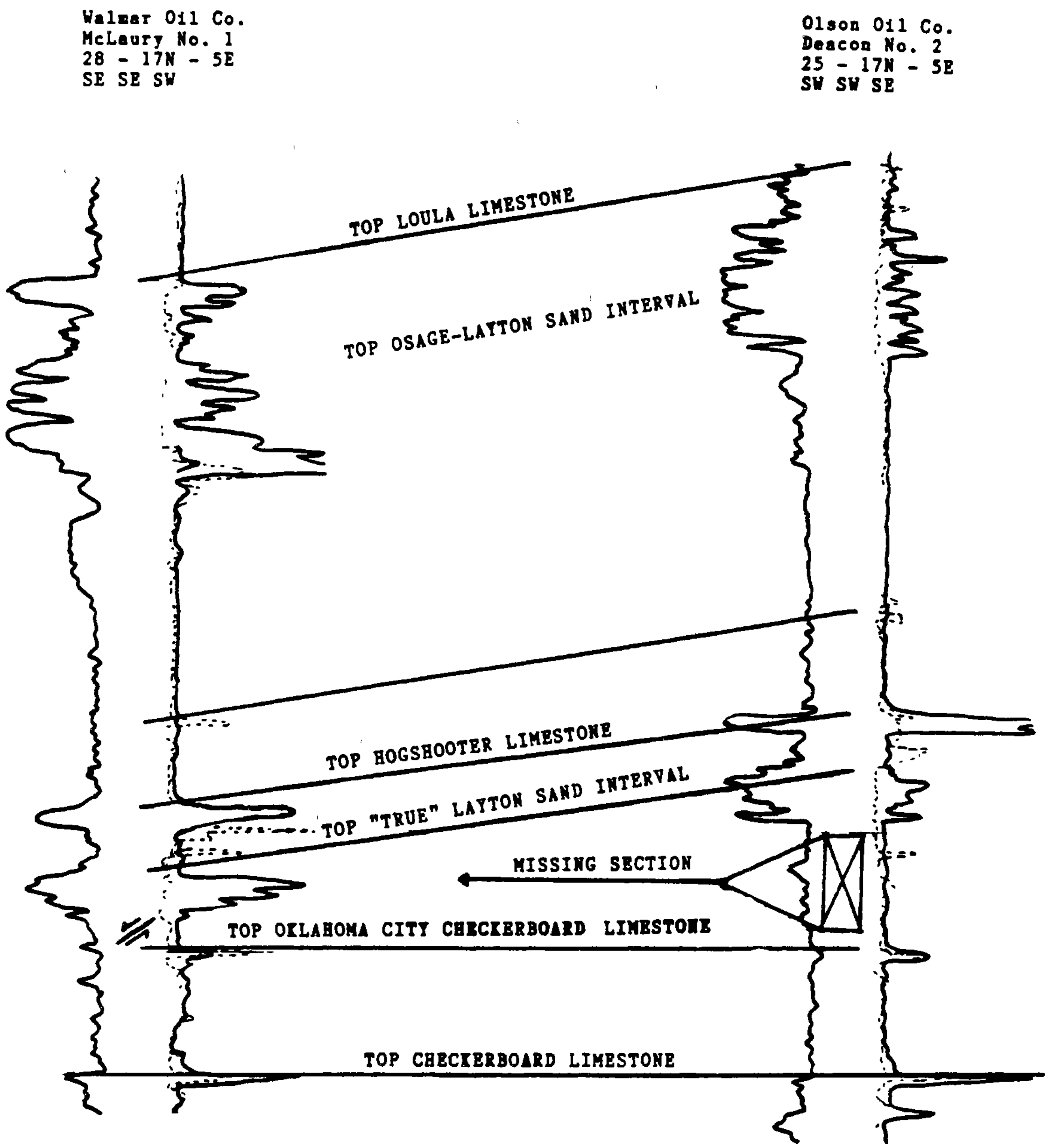

Figure 8. Fault Between "True" Layton Sandstone and Oklahoma "City" Checkerboard Limestone, Walmar Oil Co., McLaury No. 1

faults in the basement rocks. His evidence was twofold: (1) lengths and throws of faults generally increase with depth and show marked differences above and below major unconformities, and (2) limbs of folds generally show steeper dip and more closure below post-Mississippian and post-Hunton unconformities than above. Kochick (1978) recorded a similar relationship. Powers (1931) and Lyons (1950) believed that structures showing greater closure at depth are results of differential vertical uplift of basement rocks. Ireland (1955) suggested that the Ingalls anticline and the Pratt dome are related to topographic highs on the Precambrian erosional surface (Figure 9).

Comparison of structural contour maps of the Loula and Checkerboard markers (Plates 7 and 11) shows evidence of increased structural closure with depth on the S. Norfolk, Ripley, Ingalls, Starr Valley, Lost Creek, Norfolk-1, and the West Norfolk-1 anticlines. Shelton and others (1985) stated that subtle Pennsylvanian folds commonly reflect deeper and more strongly deformed structural features. Examples they cited were the west-northwest trend of the Cushing Townsite, March, and Broyles fields, the Ingalls-Hope structure, the Mehan fields, and the Ripley field. The increased structural closure with depth supports the hypothesis that the structural make-up of the area is related to recurrent movement of the basement rock (Powers, 1931). Some of the smaller anticlinal folds may have been

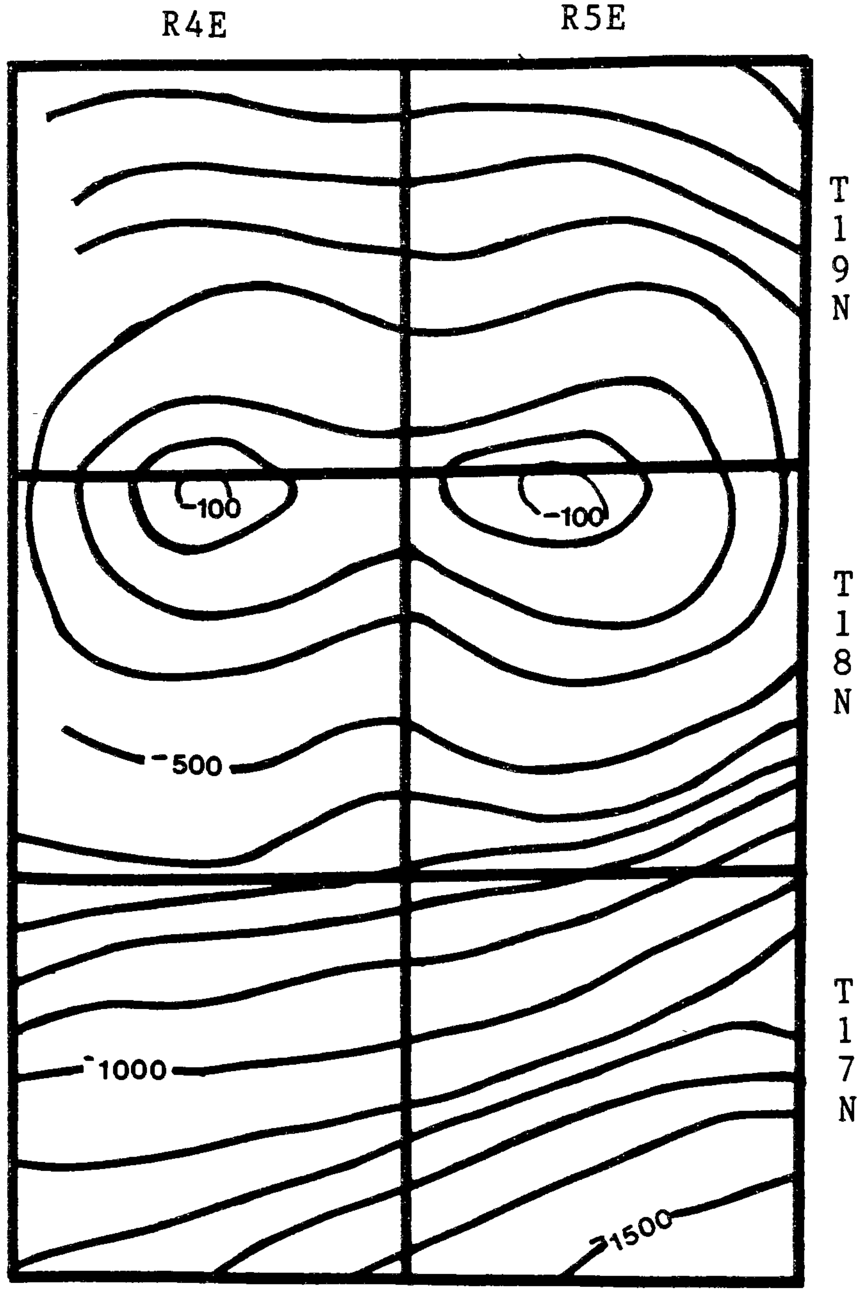

Figure 9. Topography of Surface of Precambrian Rocks, as Approximated by Thickness of Strata Older than Simpson Group (Ordovician). (After Ireland, 1955, p. 470)

caused by differential compaction above thick bodies of sand.

CHAPTER IV

GEOLOGY OF THE "TRUE" LAYTON SANDSTONE

The depositional environment of the "True" Layton sandstone has been reported as having been deltaic, in a shallow epeiric sea (Visher, Ekebafe, and Rennison, 1975). Visher and others (1975) constructed a net-sand isolith map of the "True" Layton sandstone interval. They showed that a major distributary extended into the study area from the northeast (Figure 10).

The isopach map of the interval between the top of the Checkerboard Limestone and the top of the Hogshooter Limestone (Plate 12) shows the interval to be thickest in Township 19 North, Range 5 East; however, several other thick trends are mapped in the study area (Plate 12). Thickness of the "True" Layton interval ranges from 400 ft. (T19N, R5E) to less than 270 ft. (T17N, R3E).

Several anomalous "thicks" and "thins" occur in the "True" Layton sandstone interval (Plates 12). The majority of thicks and thins are believed to be results of differential compaction above thick deposits of sandstone. Some of the anomalous thins in the study area may be reflections of paleotopographic "highs" that existed when the "True" Layton interval was deposited.

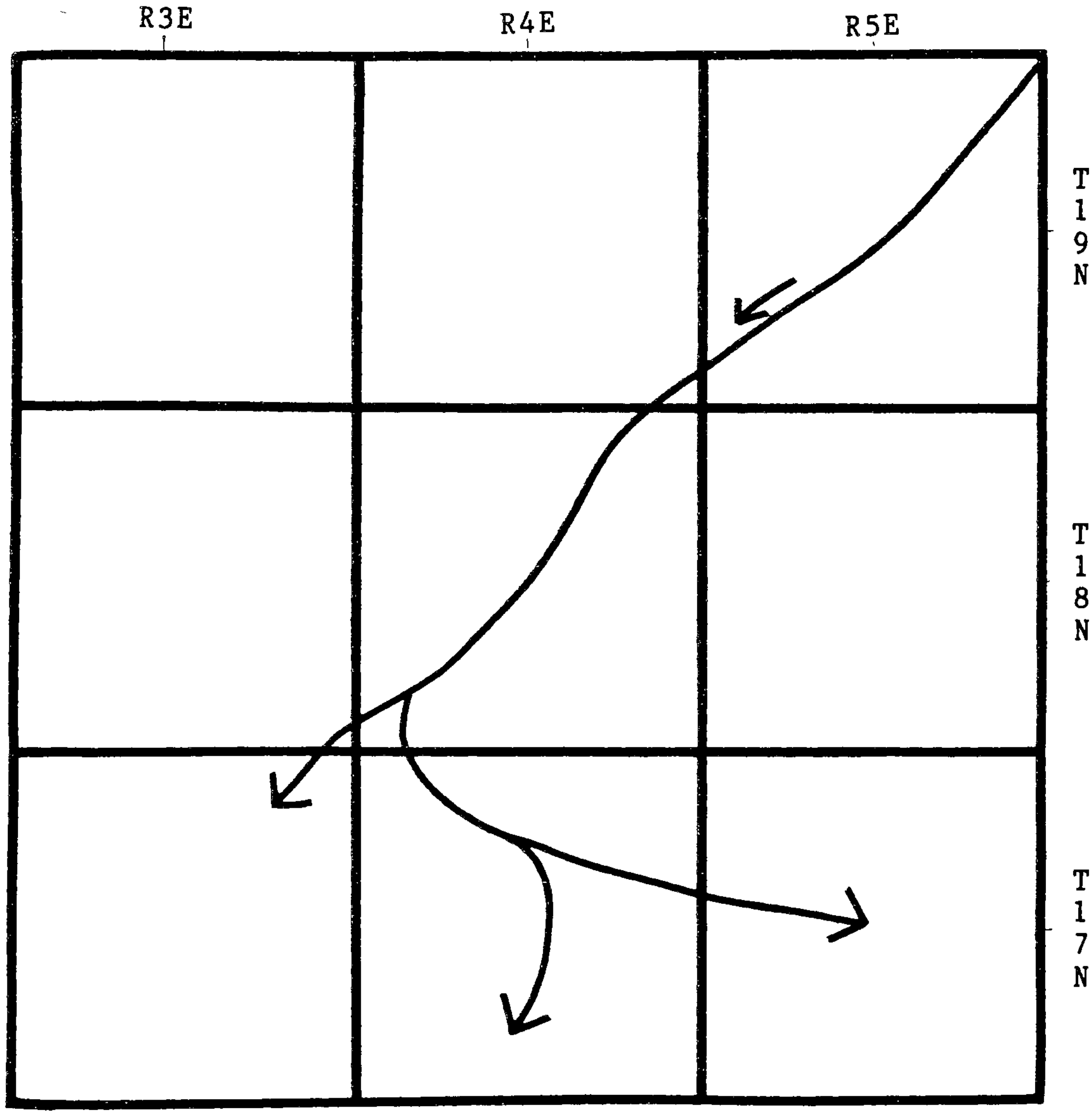

Figure 10. Trend of Distributary of "True" Layton Interval (After Visher, Ekebafe, and Rennison, 1975)

Cross-Sections

Three north-south and three east-west cross sections (Plates 1-6) show that within the "True" Layton interval the amount of sandstone and shale vary markedly both vertically and laterally. Figure 11 shows the degree to which the amounts of sandstone and shale vary throughout the study area.

Composition

Lithology of the "True" Layton sandstone was determined by visual inspection of bit cuttings from the Magnum Energy Incorporated, Nancy No. 1 (Appendix B), and from X-ray diffraction and thin-section analysis of samples from a core of the "True" Layton sandstone. The core is from a well located in section 23, T17N, R7E (Grace Petroleum Corporation, Bair No. 12). The X-ray diffraction patterns, petrologic log and photographs of the "True" Layton core are in Appendix C.

The "True" Layton sandstone is silty to very fine grained, subrounded, and moderate to well sorted sublitharenite (based on a QRF plot using Folk's sandstone classification scheme). Detrital constituents identified from the cuttings, X-ray diffraction, and thin sections are quartz, orthoclase, muscovite, plagioclase, microcline, glauconite, chert, chlorite, and rock fragments of shale, siderite, and siltstone. Photomicrographs of microcline, quartz, chert, siltstone, muscovite, plagioclase, and

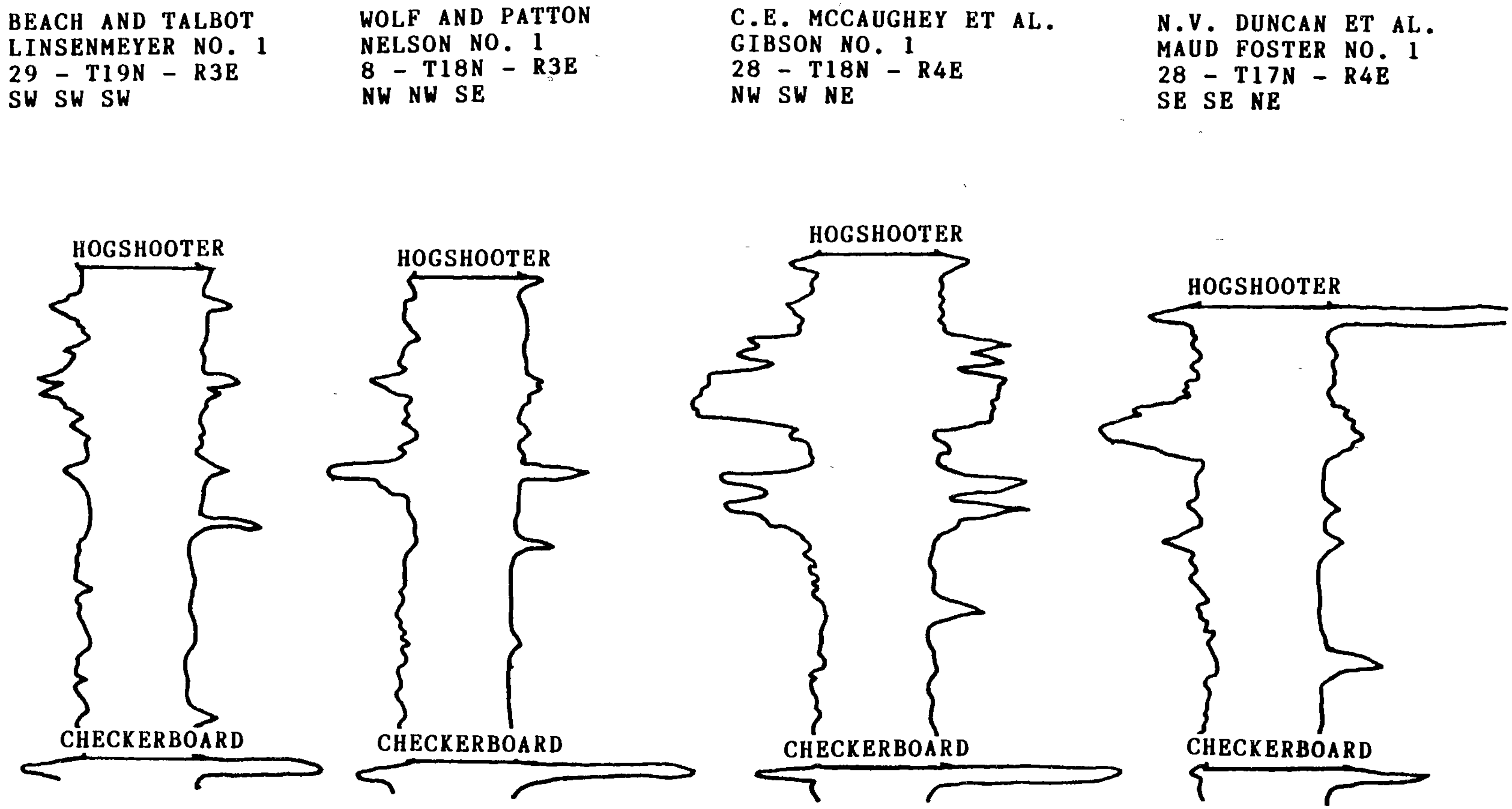

Figure 11. Four Electric Logs Showing the Degree to Which the Amounts of Sandstone and Shale in the "True" Layton Interval Vary Within the Study Area

glauconite are shown in Figures 12 through 17. Detrital matrix in the "True" Layton sandstone identified from X-ray diffraction and thin sections is illite, muscovite, and chlorite.

Authigenic constituents observed within thin sections and X-ray diffraction patterns are chlorite, kaolinite (Figures 16 and 17), quartz overgrowths (Figure 18), illite (Figure 19), anhydrite cement (Figure 20), and carbonate cement (Figure 21).

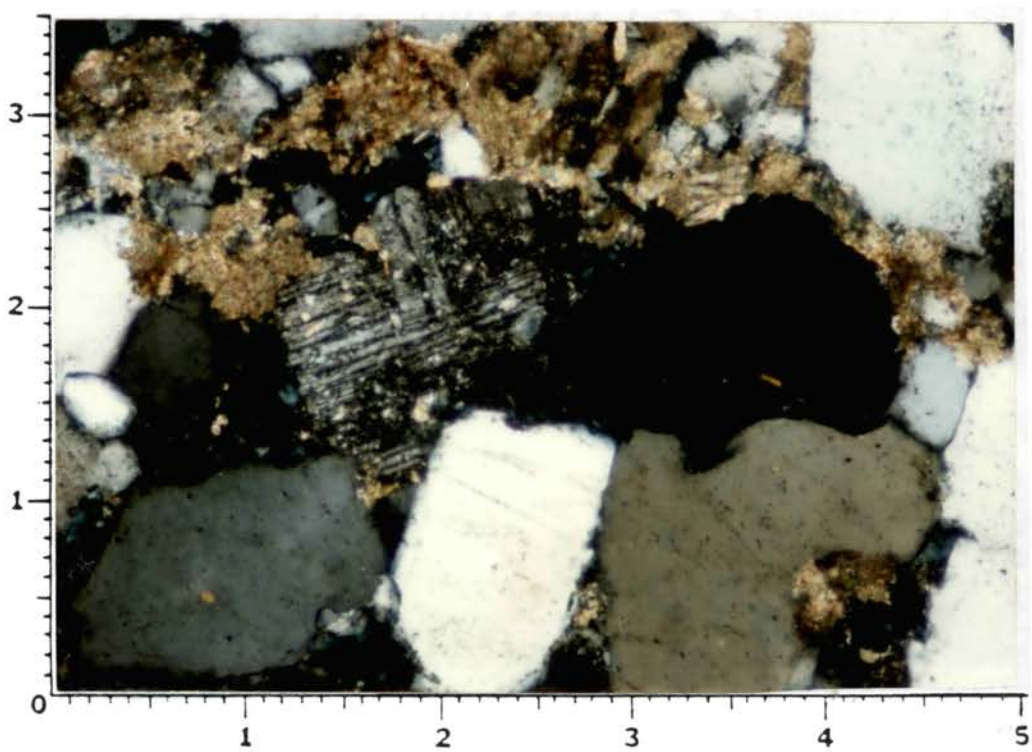

Figure 12. Thin-section Photomicrograph, Crossed Nicols 10X. Microcline (2.0, 2.0), Calcium Carbonate (1.8, 3.0), and Quartz (2.2, 0.5).

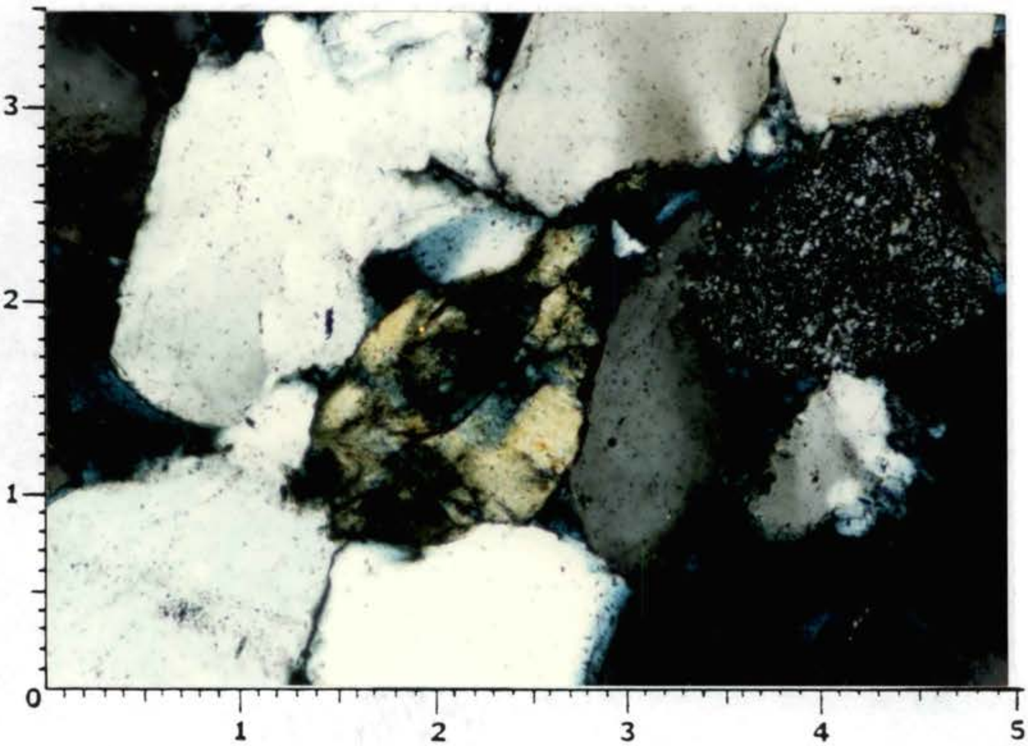

Figure 13. Thin-section Photomicrograph, Crossed Nicols, 10X. Chlorite (2.1, 1.5) and Chert (4.0, 2.2)

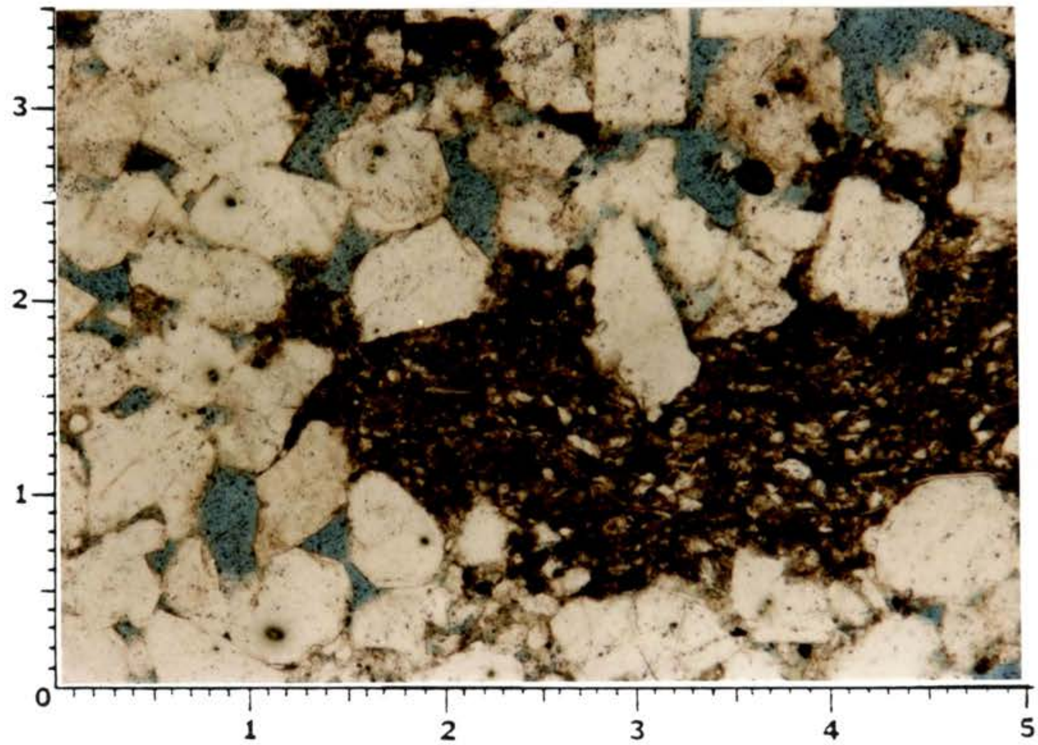

Figure 14. Thin-section Photomicrograph of Siltstone (3.0, 1.4), Plane Polarized Light, 4X

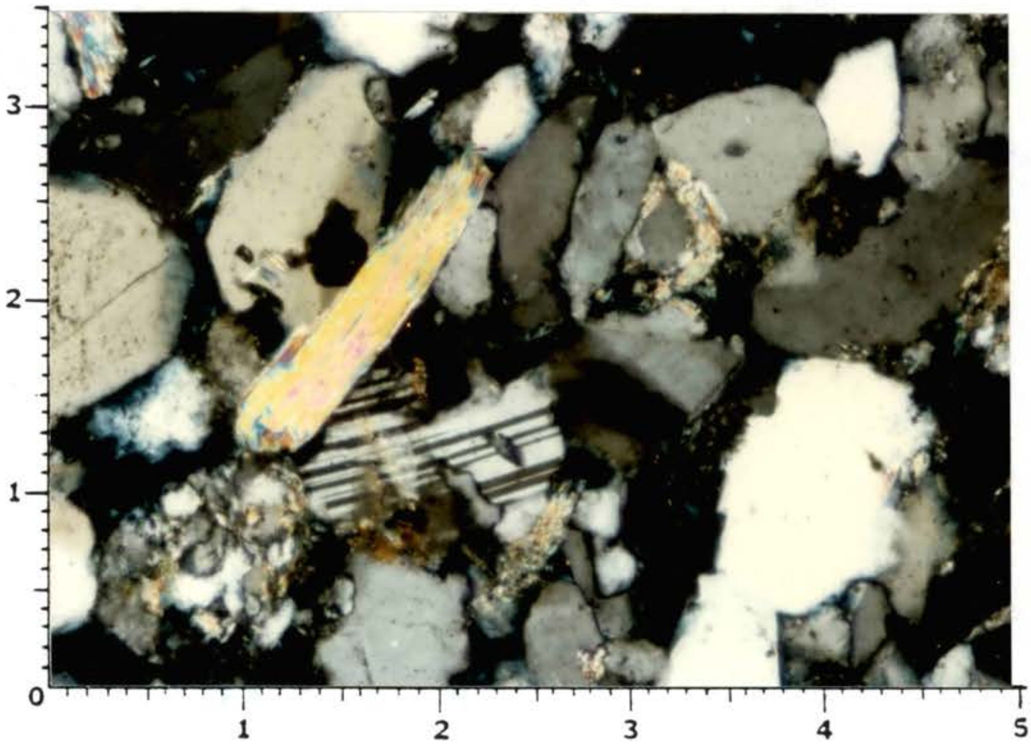

Figure 15. Thin-section Photomicrograph, Crossed Nicols, 10X. Muscovite (1.6, 1.8) and Plagioclase (2.4, 1.3)

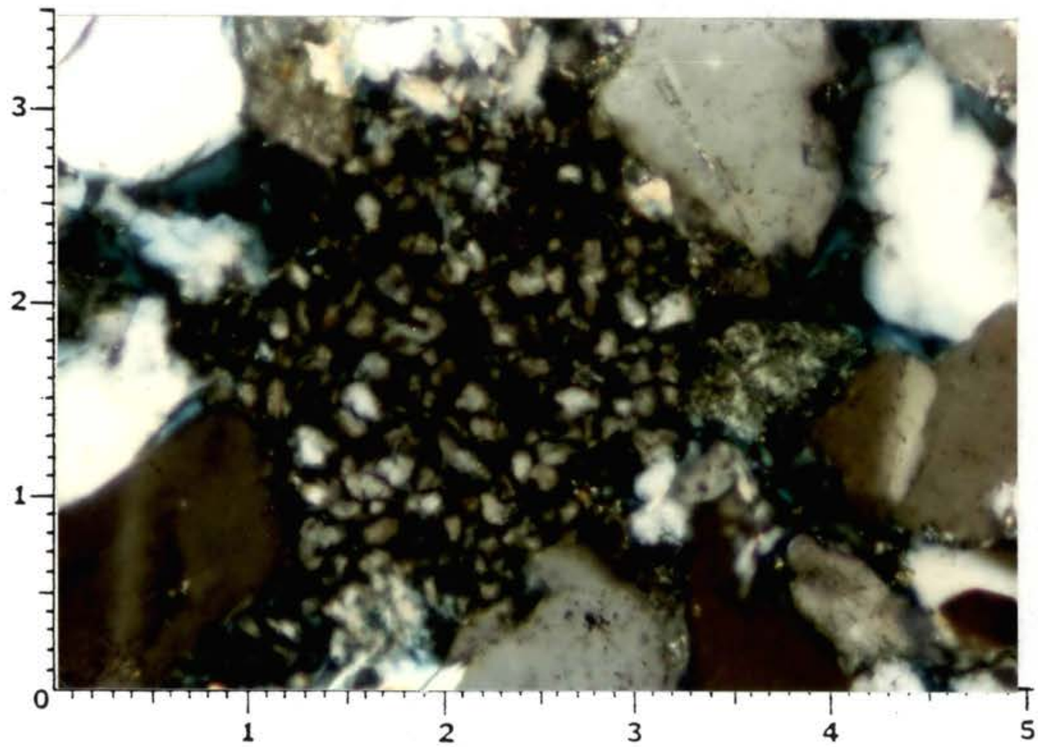

Figure 16. Thin-section Photomicrograph, Crossed Nicols, 20X. Kaolinite (2.0, 1.8) and Glauconite (3.7, 1.7).

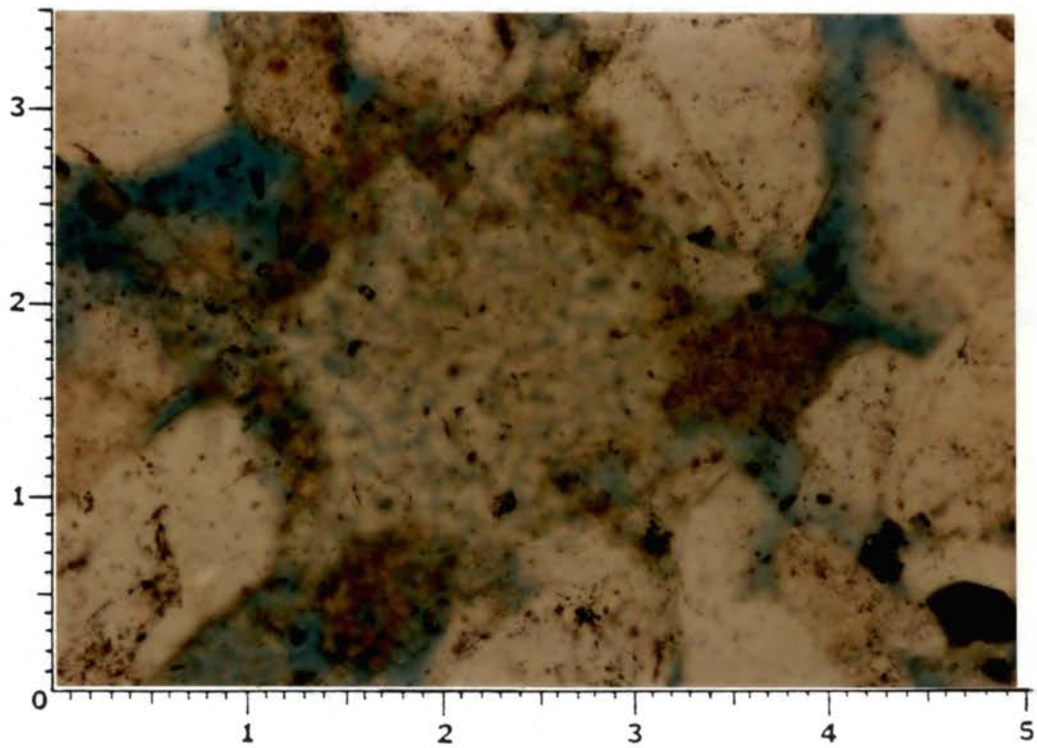

Figure 17. Thin-section Photomicrograph, Plane Polarized Light, 20X. Kaolinite (2.0, 1.8) and Glauconite (3.7, 1.7).

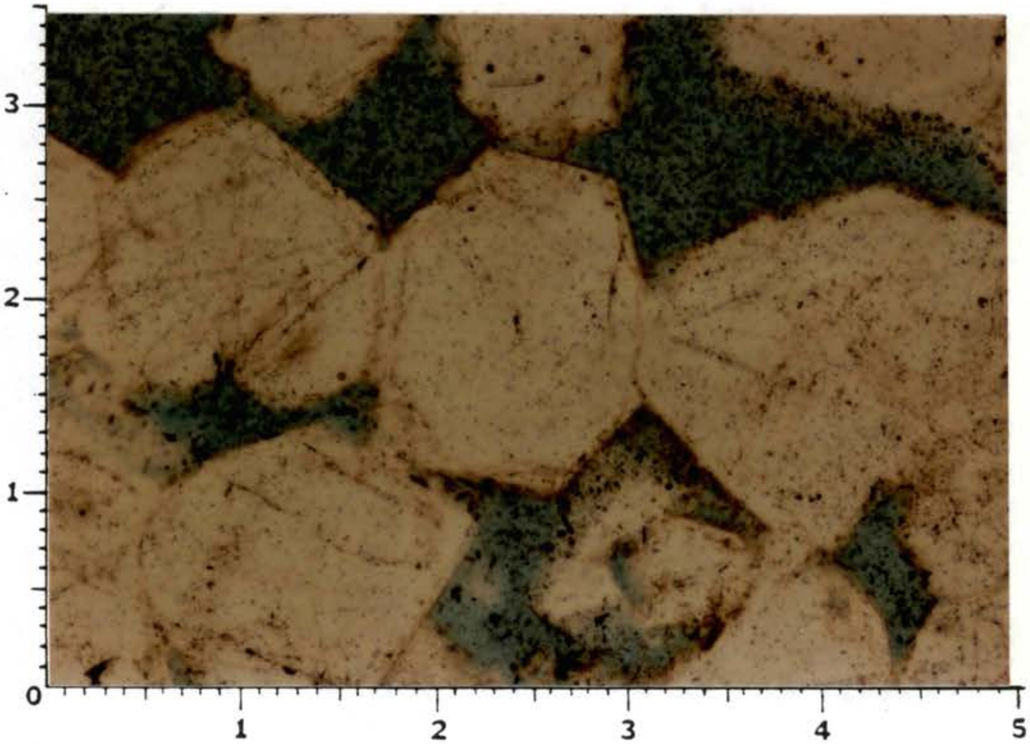

Figure 18. Thin-section Photomicrograph of Quartz Grain with Quartz Overgrowth (2.7, 2.5), Plane Polarized Light, 10X

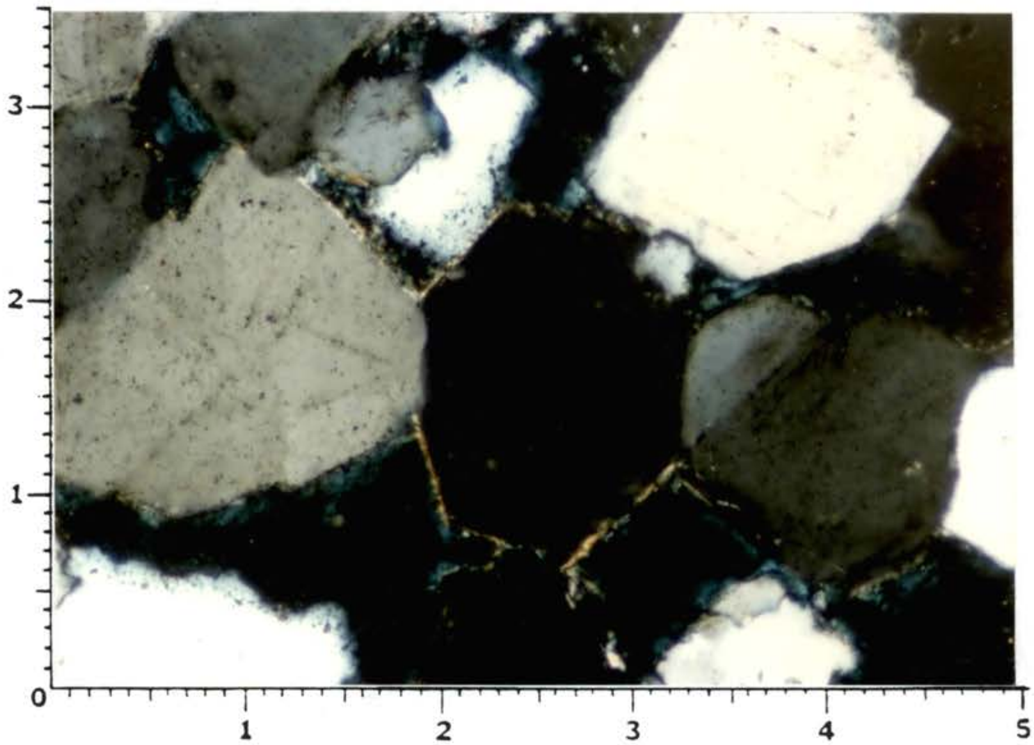

Figure 19. Thin-section Photomicrograph of Quartz
Quartz Overgrowth with Illitic Rim
(2.2, 2.0), Crossed Nicols, 10X

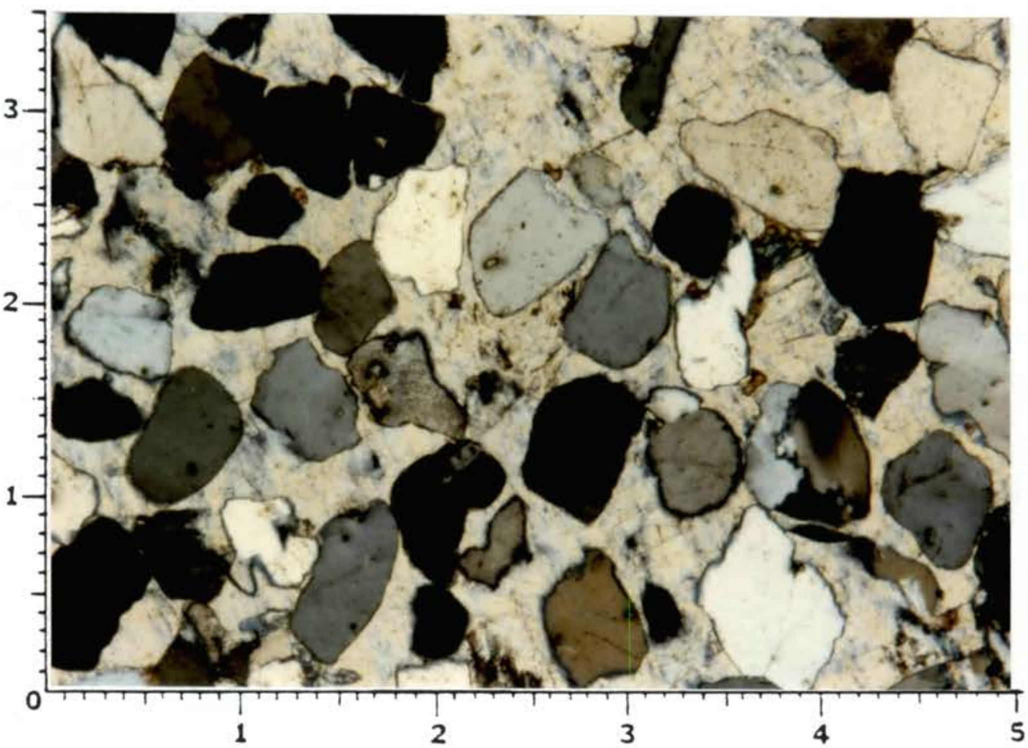

Figure 20. Thin-section Photomicrograph, Crossed Nicols, 4X. Anhydrite Cement Displacing and Replacing Framework Grains

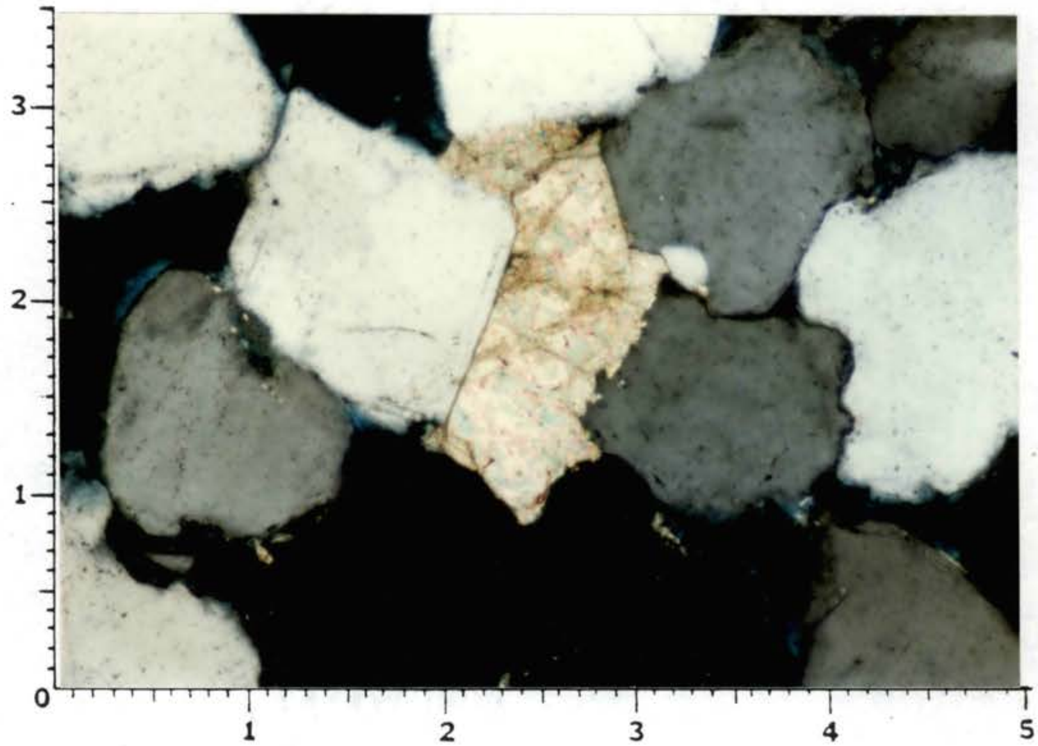

Figure 21. Thin-section Photomicrograph, Carbonate Cement (1.6, 2.5), Crossed Nicols, 10X

CHAPTER V

GEOLOGY OF THE OSAGE-LAYTON SANDSTONE

The general depositional setting of the Osage-Layton sandstone in northeastern Oklahoma has been reported as deltaic (Lalla, 1975). Lalla (1975) constructed a net-sand isolith map of the Osage-Layton sandstone in the region bounded by Townships 14 and 29 North, and Ranges 1 and 13 East. He showed evidence that a major distributary extended into the present study area from the southwest (T17N, R5E) (Figure 22). The isopach map of the interval between the top of the Hogshooter Limestone and the top of the Loula limestone (Plate 13) shows the interval to be thickest in the southeast (T17N, R5E) and thinning to the northwest (T19N, R3E); this circumstance suggests that the source area of the Osage-Layton lay to the southeast. Thickness of the Osage Layton interval ranges from 450 ft. in the southeastern part of the study area to less than 280 ft. in the northwestern part (Plate 13).

The isopach map of the interval between the top of the Hogshooter Limestone and the top of the Loula limestone (Plate 13) shows that several areas are anomalously thick or thin. Most of the "thicks" and "thins" are believed to

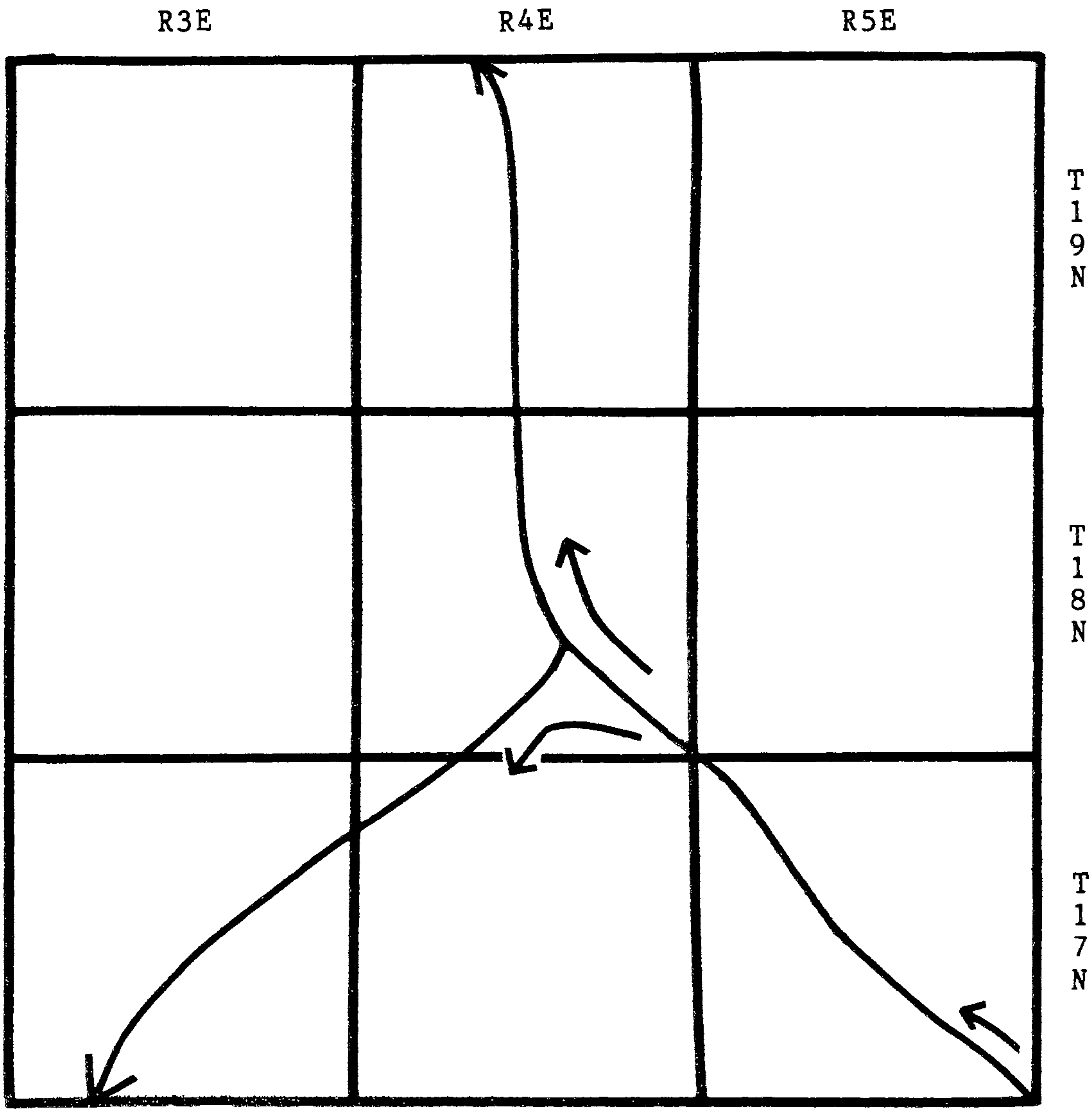

Figure 22. General Trend of Distributary-channel Sandstone in Osage-Layton Interval (After Lalla, 1975).

be results of differential compaction above thick bodies of sandstone and shale. Some of the areas where the interval is thin may be located where paleotopographic "highs" existed before and during deposition of the Osage-Layton interval.

Cross-Sections

Six stratigraphic cross-sections (Plates 1-6) show general positions at which sandstones occur within the Osage-Layton interval. The three east-west cross sections (Plates 4 through 6) show that the lower part of the Osage-Layton sandstone grades into shale to the east and southeast. Figure 23 indicates the degree in which the amount of sandstone and shale development varies throughout the study area.

Composition

Bit cuttings from the Avant Limestone-to-Checkerboard Limestone interval, from the Magnum Energy Incorporated, Nancy No. 1 (Appendix B), section 7, T19N, R7E were described by visual inspection using 10-power to 20-power magnification. Two thin sections composed of cuttings from the Osage-Layton sandstone interval were studied.

Sandstone of the Osage-Layton is silty to very fine grained, subangular to subrounded, and moderately sorted to well sorted. Detrital constituents are quartz grains with inclusions, feldspar, metamorphic-rock fragments, muscovite, bohem, and zircon. Photomicrographs of quartz, zircon, and bohem are shown in Figures 24 and 25.

Diagenetic constituents observed in thin sections are quartz overgrowths, calcite cement (Figure 26), and pyrite.

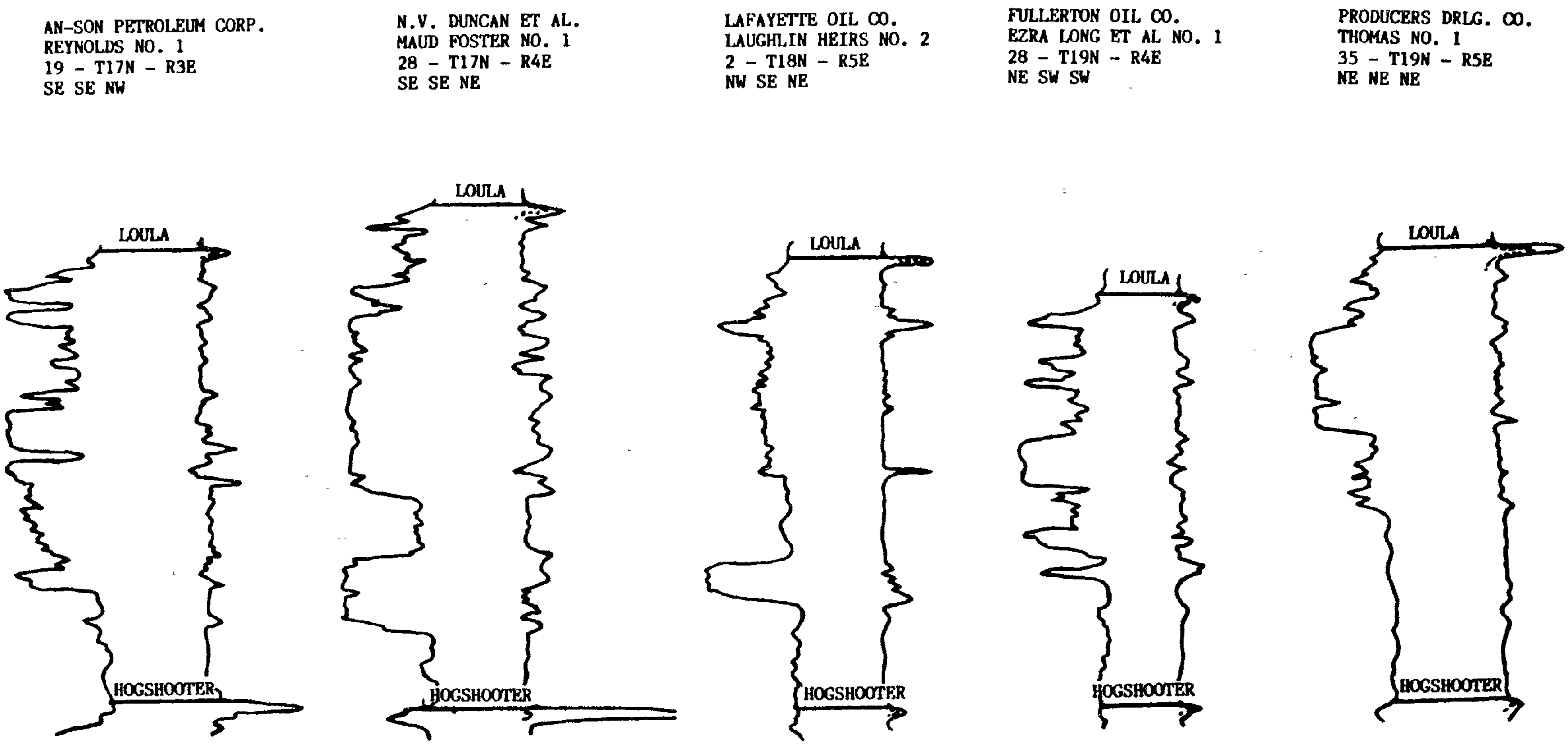

Figure 23. Tracings of Six Electric Logs that Suggest the Degree of Variation Between Sandstone and Shale in the Osage-Layton Interval

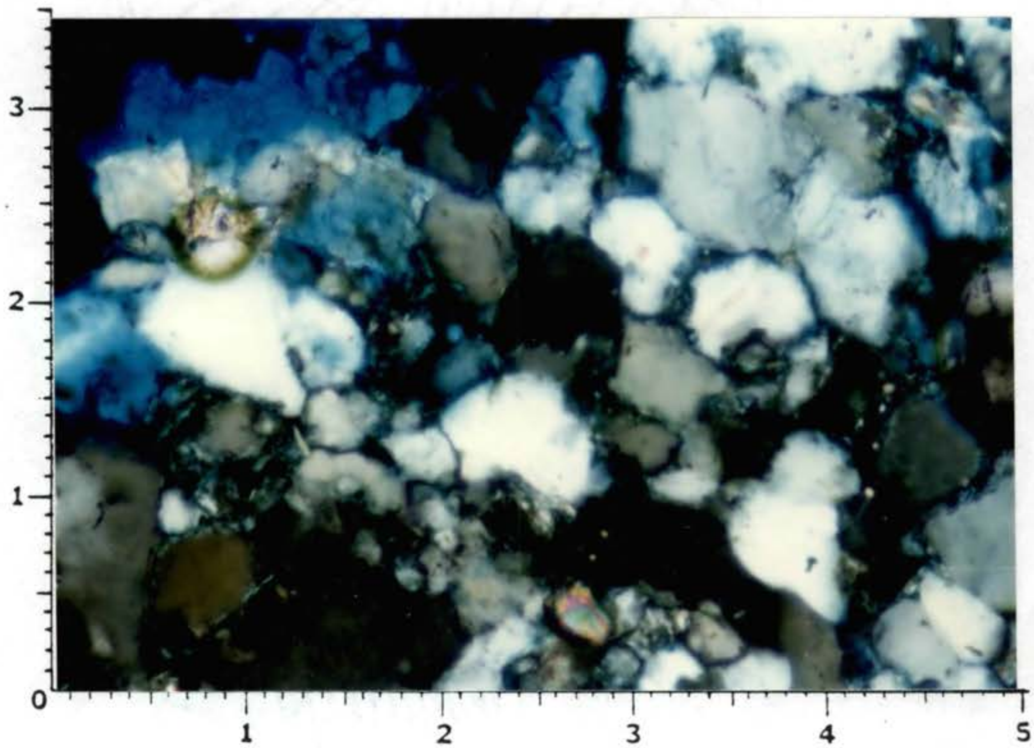

Figure 24. Thin-section Photomicrograph, Crossed Nicols, 20X. Zircon (0.4, 2.8) and Quartz (1.4, 2.5)

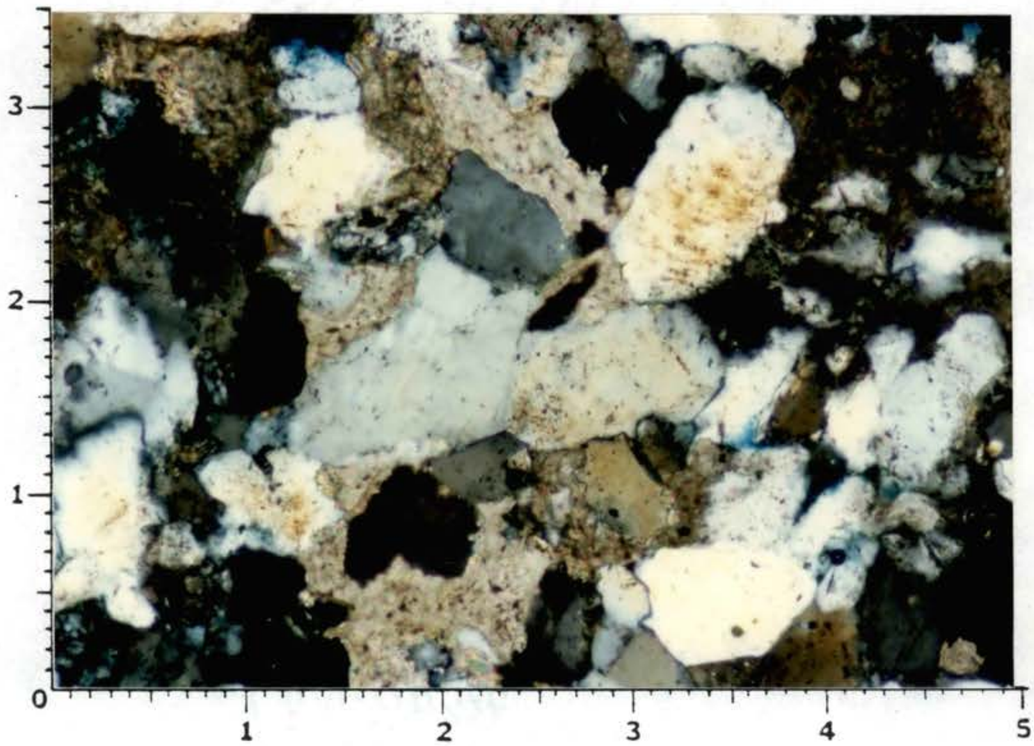

Figure 25. Thin-section Photomicrograph, Crossed Nicols, 10X. Calcium Carbonate Cement (0.3, 1.8) and Bohem (2.3, 3.3)

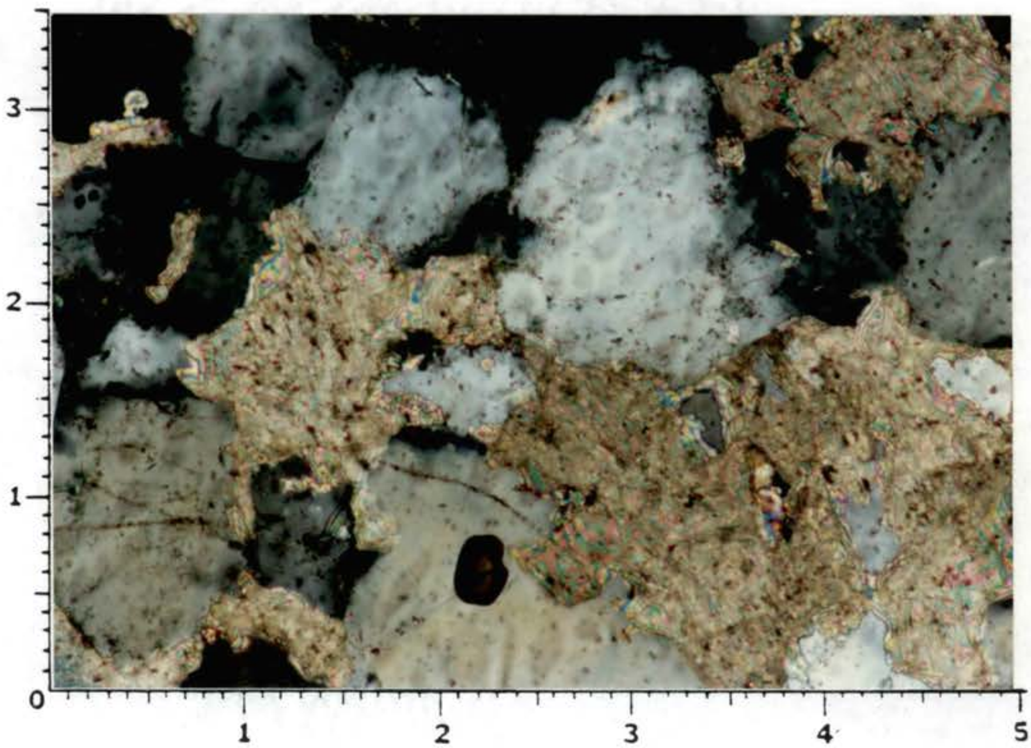

Figure 26. Thin-section Photomicrograph, Crossed Nicols, 20X. Quartz Grains with Inclusions (0.5, 2.2) and Carbonate Cement (1.0, 3.0).

CHAPTER VI

GENERAL PETROLEUM GEOLOGY OF THE "TRUE" LAYTON SANDSTONE

In the study area five wells produce oil and gas from the "True" Layton sandstone. Table 1 shows information about locations, field names, years in which wells were drilled, initial production, and gravities of the oil. (Information in Table 1 and other tables was compiled from records published by Petroleum Information Co.)

The trap at the N. March field is controlled by sandstone of the "True" Layton folded over a domal anticline (Figure 27). The trap at the Sporn field is controlled where sandstone of the "True" Layton pinches out up-dip (Figure 28). In the Cushing Townsite field, entrapment of oil is believed to be a combination of stratigraphic and structural conditions, in which the "True" Layton sand is folded over the Cushing Townsite anticline. The trap in the Norfolk field is controlled by sandstone of the "True" Layton folded over the Norfolk domal structure (Figure 29).

Data concerning cumulative production from the "True" Layton sandstone were not available in most cases, because

TABLE 1

WELLS PRODUCING FROM "TRUE" LAYTON SANDSTONE

Location	Field	Year Drilled	Gravity	Initial Production
Ryan No. 5 34-18N-5E SW SW SW Ryan #5	Cushing Townsite	OWWO 1967	?	Natural 500,000 CFGPD & 6 BO/24 hrs.
Koble No. 1 12-18N-5E NE SW SW	Norfolk	1964	45.5	P 77 BO & 385 BSW/24 hrs.
Koble No. 3 12-18N-5E SE SW SW	Norfolk	1964	45.6	P 40 BO & 185 BSW & 75,000 CFG/24 hrs.
Bryant No. 1-A 7-18N-5E N1/2 NE NE	N. March	1963	?	F 2,420,000 CFGPD
Schroeder No. 1 20-17N-3E N1/2 NE SW	Sporn	1983	?	?

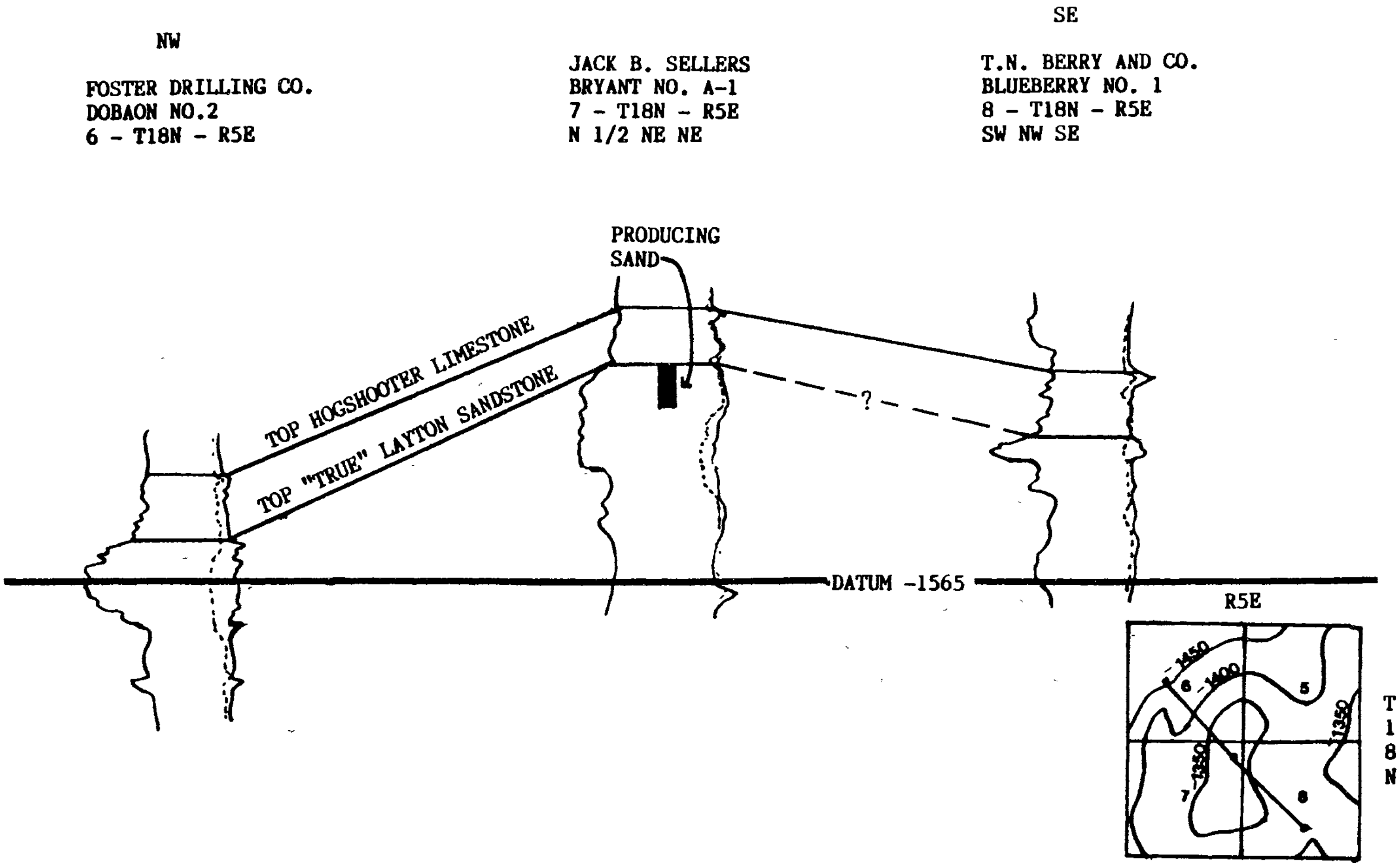

Figure 27. Structural Cross-section Across the North March Oil Field. Structural Contour Map of Top of Hogshooter Limestone

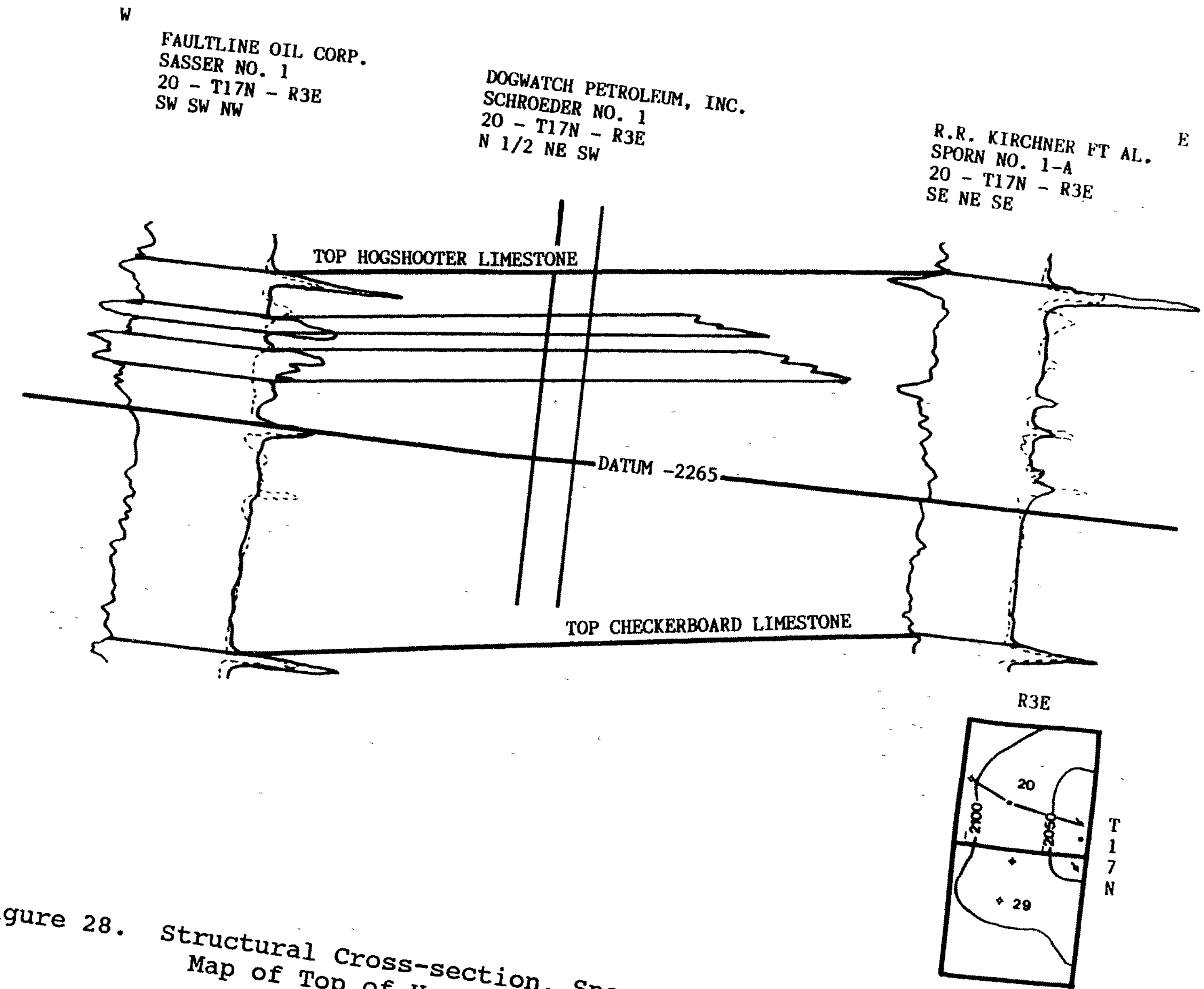

Figure 28. Structural Cross-section, Sporn Field. Structural Contour Map of Top of Hogshooter Limestone

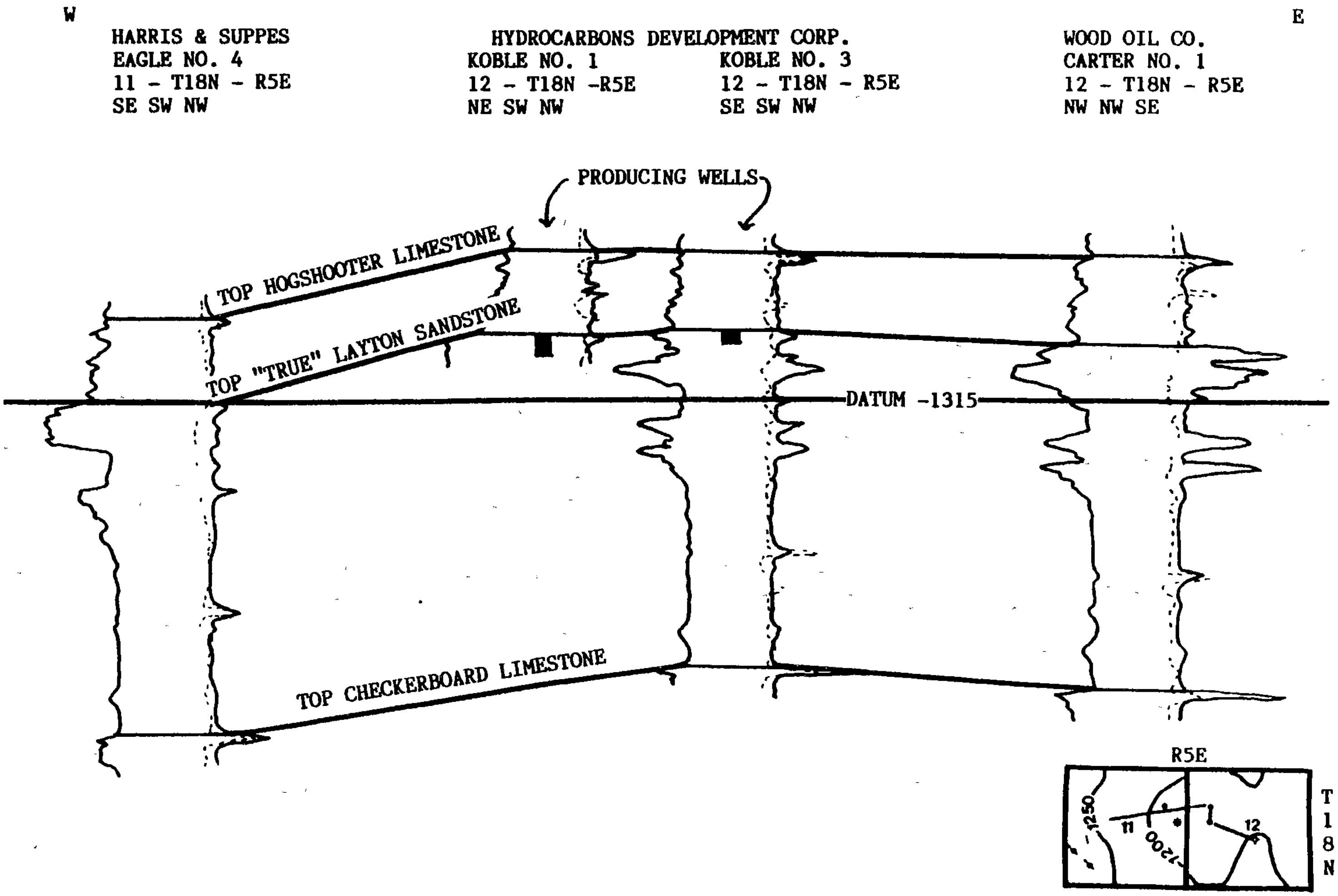

Figure 29. Structural Cross-section, Norfolk Field. Structural Contour Map of Top of Hogshooter Limestone

oil and gas from the "True" Layton was commingled with petroleum from other zones. However, production curves of the Hydrocarbons Development Corporation Koble No. 1 and Koble No. 3 are shown in Figure 30.

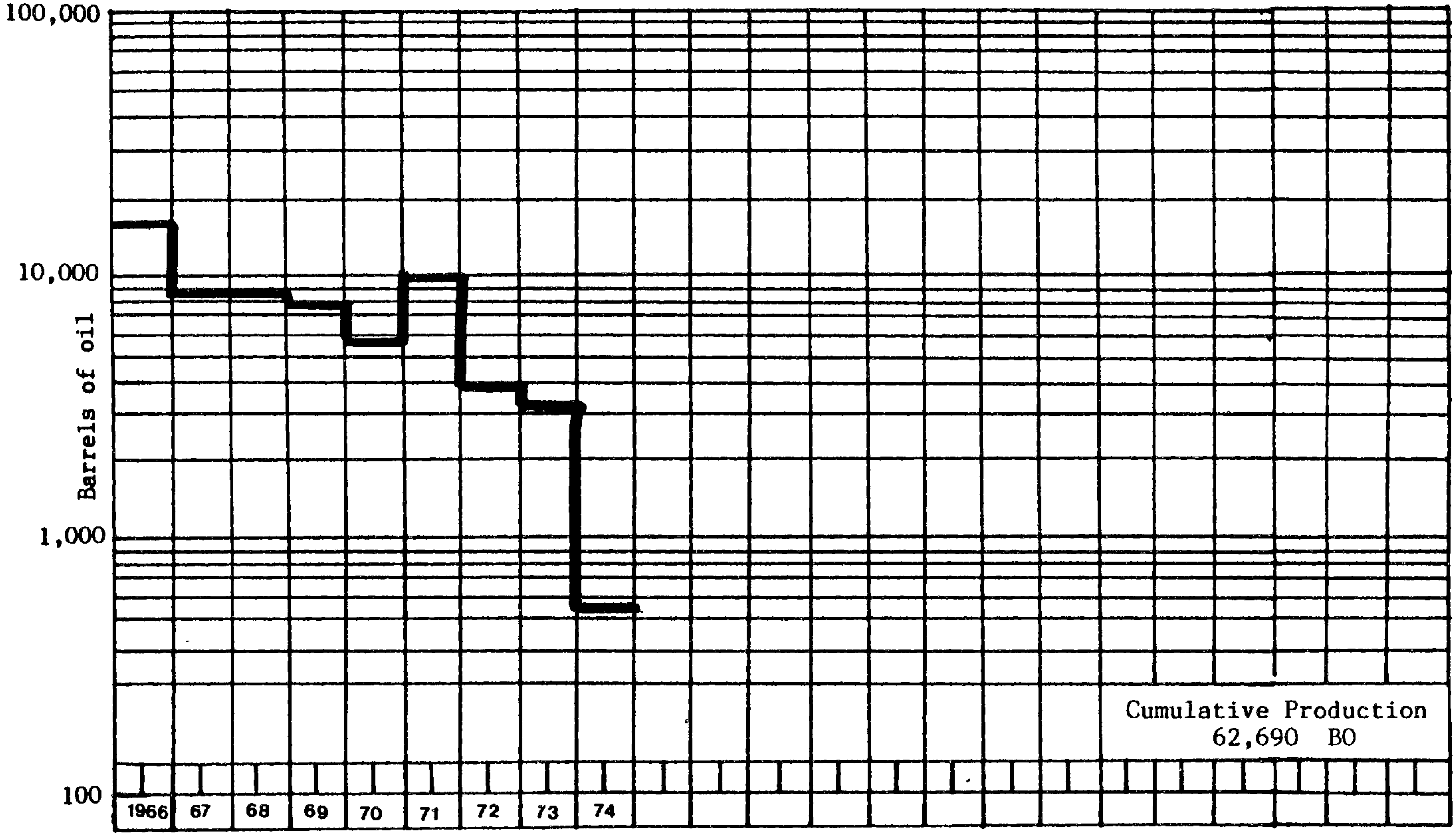

Figure 30. Production-decline Diagram of the "True" Layton Sandstone. Commingled Production from Hydrocarbons Development Corp., Koble No. 1 and Koble No. 3, Section 12,T18N,R5E, Norfolk Field

CHAPTER VII

GENERAL PETROLEUM GEOLOGY OF THE OSAGE-LAYTON SANDSTONE

In the study area oil and gas are produced from the Osage-Layton sandstone in seven fields (Figure 31). The first reported production from Osage-Layton sandstone in the study area was in 1944 during development of the N.E. Mehan and Broyles fields. Table 2 shows numbers of producing wells, discovery dates, cumulative production values of oil and gas (as of May, 1988), and gravities of the oil in fields where the Osage-Layton sandstone has been productive. Total yields from individual wells and fields were not available in many instances, because oil and gas from the Osage-Layton was commingled with production from other zones.

Entrapment of Petroleum in the Osage-Layton Sandstone

Most of the oil and gas produced from the Osage-Layton sandstone in the study area is from combination stratigraphic and structural traps. In the seven fields referred to in Table 2, oil and gas are produced where

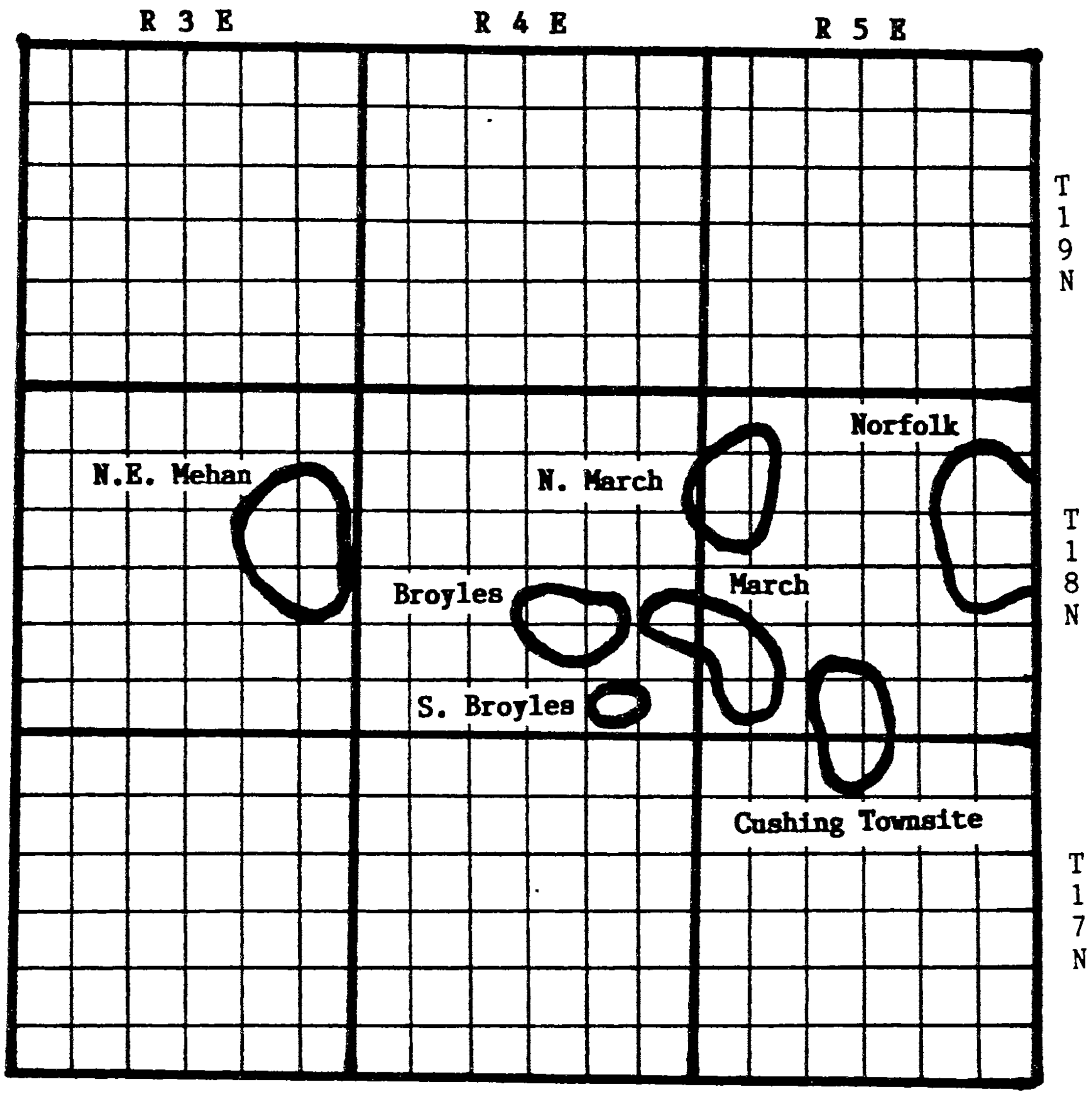

Figure 31. Locations of Oil and Gas Fields Where the Osage-Layton Sandstone is Productive

TABLE 2

FIELDS WHERE PETROLEUM HAS BEEN PRODUCED FROM OSAGE-LAYTON SANDSTONE

Field Name	No. of Wells	Year Discovered	Cumulative Production	API Gravity of Oil
N. Ripley	1	1964	?	________
N.E. Mehan	11	1944	commingled	44 to 47 Avg. 46
S. Broyles	12	1963	287,496 BO from 9 of 12 wells	44 to 47 Avg. 46
Broyles	10	1944	438,075 BO from 6 of 10 wells	44 to 47 Avg. 46
March	9	1954	131,843 BO from 5 of 9 wells	40 to 48 Avg. 45
Cushing Townsite	4	1964	368,695 BO from 3 of 4 wells	41 to 48 Avg. 45
Norfolk	13	1963	99,830 BO from 3 of 13 wells	39 to 44 Avg. 41

Note: Information from records published by Petroleum Information Co.

thick bodies of sandstone are within 80 ft. from the base of the Loula marker bed (Plates 16 and 19).

The structural contour map of the top of the Osage-Layton sandstone (Plate 10) shows evidence of several structural domes and anticlinal noses. However, the Osage-Layton has not been productive on these structural features, except where sandstone within 80 ft. below the Loula Limestone is well developed. The Osage-Layton sandstone is multistoried; the several units seem to be without effective seals. Thus, petroleum could have migrated vertically and laterally, to accumulate only where in the upper bodies of sandstone pinch out in structurally "high" localities.

The trap in the northern part of the Broyles field occurs where the Osage-Layton sandstone pinches out on an anticlinal nose (Plates 17, 18, and 19). Traps elsewhere at the Broyles field, and at March, S. Broyles, Cushing Townsite, Norfolk, and N.E. Mehan fields are developed where the upper Osage-Layton sandstone is folded entirely over domal structures (Plates 14 through 19).

The March field (Plate 17) has approximately 90 ft. of structural closure at the position of the Loula marker bed. Production of the Osage-Layton sandstone occurs where the upper productive sandstones are well developed (Plates 18 and 19) on this fold. Thickness of the producing sandstone units ranges from less than 10 ft. to more than 20 ft. (Plates 18 and 19).

At the Broyles field (Plate 17), structural closure at the position of the Loula limestone is about 35 ft. Thickness of the Osage-Layton sandstone ranges from less than 10 ft. to more than 20 ft. (Plate 19).

At S. Broyles field (Plate 17), structural closure at the position of the Loula limestone is about 40 ft. The Osage-Layton sandstone produces oil and gas where the upper sandstones are well developed (Plates 18 and 19) on the fold. Thickness of the producing sandstone units ranges from less than 20 ft. to more than 30 ft. (Plate 19).

The Cushing Townsite structure (Plate 17) has over 100 ft. of closure at the position of the Loula limestone. Production from the Osage-Layton occurs where more than 30 ft. of the upper productive Osage-Layton sandstone units are developed, on the southeastern part of the flexure (Plates 17, 18, and 19).

At Norfolk field (Plate 17), closure at the position of the Loula limestone exceeds 50 ft. Osage-Layton production occurs where more than 20 ft. of the upper Osage-Layton sandstone is developed (Plates 18 and 19).

The N.E. Mehan field has approximately 90 ft. of closure (Plate 14) at the position of the Loula. The Osage-Layton produces on this fold where the upper sandstones are well developed (Plates 15 and 16). Thickness of the producing sandstone units ranges from less than 20 ft. to more than 40 ft. (Plates 15 and 16).

The N. Ripley structure (Plate 14) has approximately 80 ft. of closure at the position of the Loula limestone. However, the Osage-Layton sandstone is not productive at this location, because the upper sandstones are absent (Plates 15 and 16).

In the study area, traps in the Osage-Layton sandstone are combination stratigraphic-structural. Log-signature maps, net-sandstone isopach maps of sandstone within 80 ft. below the Loula marker bed, and structural contour maps of the Loula limestone should be a good basis for isolating areas where undrilled traps could exist.

Economic Data for Exploration

The objective in drilling a prospect based on Osage-Layton sandstone or any other prospect is to discover a pool of oil and or gas that will return a profit on the investment. Some of the important factors to consider are (1) the potential reserves in the pool, (2) histories of wells, shown by production curves, (3) amounts of time required to recover total reserves, (4) depth ranges of wells and costs of drilling and completion, and (5) profit-to-investment ratios. Table 3 shows data on six wells used to evaluate the production of Osage-Layton wells in the study area. The assumption is held that drilling would be no deeper than the Osage-Layton sandstone. Values are based on drilling and completion costs of $34/ft., price

TABLE 3

ECONOMIC EVALUATION, SIX OSAGE-LAYTON WELLS IN THE STUDY AREA
(numbers not rounded)

Operator, Well name, and Location	Field	Production Gross BO	Production Net (87%) BO	Gross Income (at $14/bbl)	Operating Expense ($6,000/yr.)	Drilling & Completion Costs[a]	Net Income ($)	Profit-Invest. Ratio
Cushing Production Co. Mosher 1 3-17N-5E NW NE SW	Cushing Townsite	192,493	167,469	$2,344,565	$126,000 21 years	$61,030 1,795′	2,218,565	36.4
Cushing Production Co. Stufflebeam#1 3-17N-5E NW NE NW	Cushing Townsite	84,756	73,738	$1,032,328	$132,000 22 years	$60,928 1,792′	839,400	13.8
J.M. Thompson Co-Op #1 34-18N-5E SW SE SW	Cushing Townsite	91,446	79,558	$1,113,812	$126,000 21 years	$60,996 1,794′	926,816	15.2
Thomas E. Berry Armento #1 24-18N-5E NE NE SW	Norfolk	48,426	42,131	$ 589,829	$ 78,000 13 years	$56,916 1,674′	454,913	8.0
T.N. Berry & Co. Thompson #1 & #2 (2 wells) 24-18N-4E SW SW NW & SE SW NW	Broyles	109,065 ÷ 2 = 54,533	47,433	$ 664,206	$150,000 25 years	$64,974 1,911′	449,232	6.0

[a]Drilling @ $15/ft.; Completion @ $19/ft.

per barrel for oil of $14, and operating costs of $6,000 per year.

Production curves of the Mosher No. 1, the Stufflebeam No. 1, and Co-Op No. 1 (Figures 32, 33, and 34) are examples of three well histories in the Cushing Townsite field. The Mosher No. 1 is the most productive of the three with cumulative production of more than 190,000 barrels of oil. For the three wells, the amounts of time required to produce the cumulative amounts was 21 to 22 years. Production diagrams of other Osage-Layton wells in the study area are in Appendix D.

Approximate profit-to-investment ratios are based on assumed net income and initial cost of drilling and completion. Ratios for the Mosher No. 1 (36:1), the Stufflebeam No. 1 (14:1), and the Co-Op No. 1 (15:1) clearly would be attractive to investors. The Arment No. 1 (8:1) and the Thompson Numbers 1 and 2 could also be considered a worthy investment under more stable economic conditions than exist at present, or if the risk in drilling were perceived to be uncommonly low.

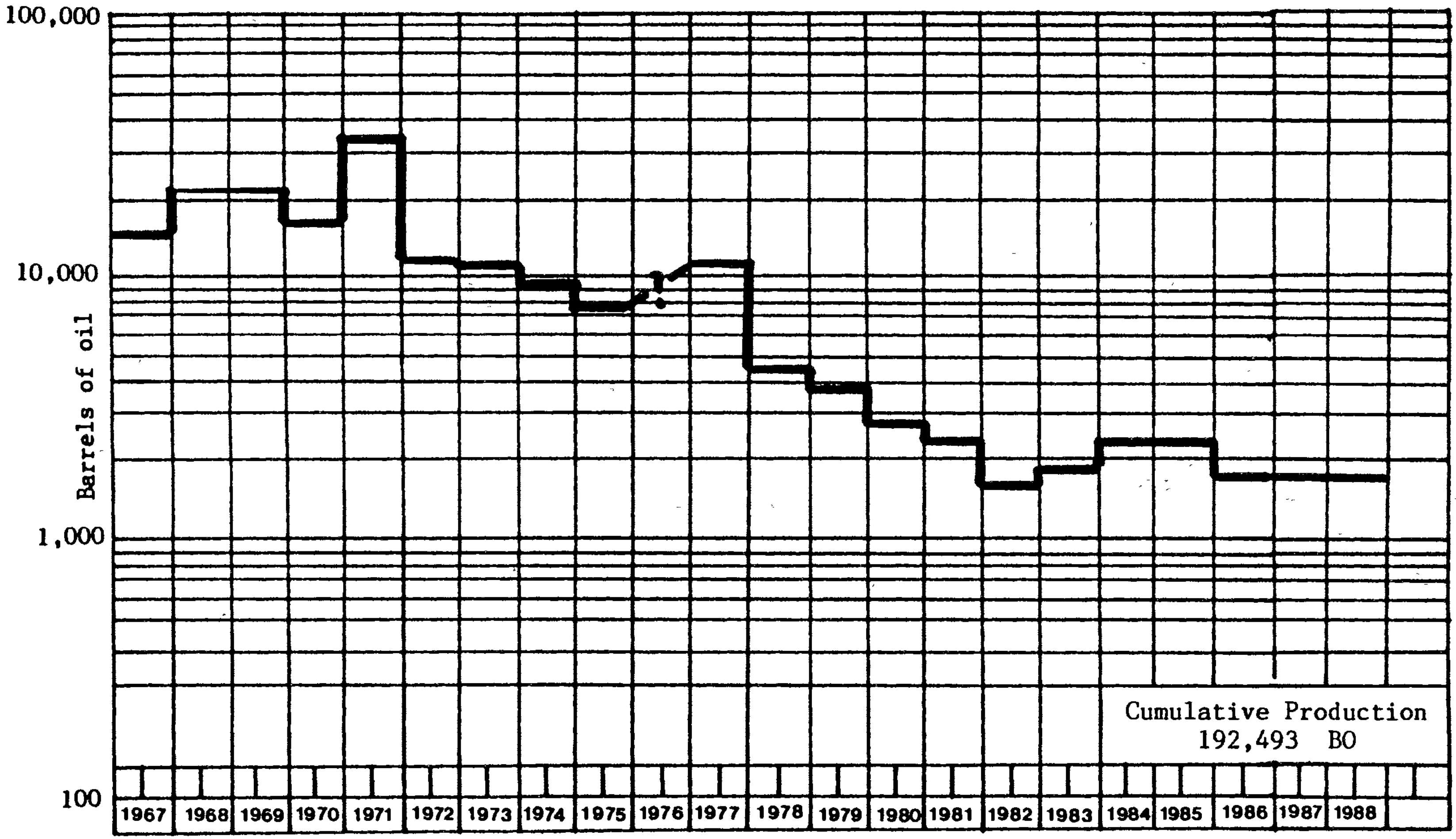

Figure 32. Production-decline Diagram, Osage-Layton Sandstone, Cushing Production Co., Mosher No. 1, Section 3, T17N, R5E, NW NW SW, Cushing Townsite Field

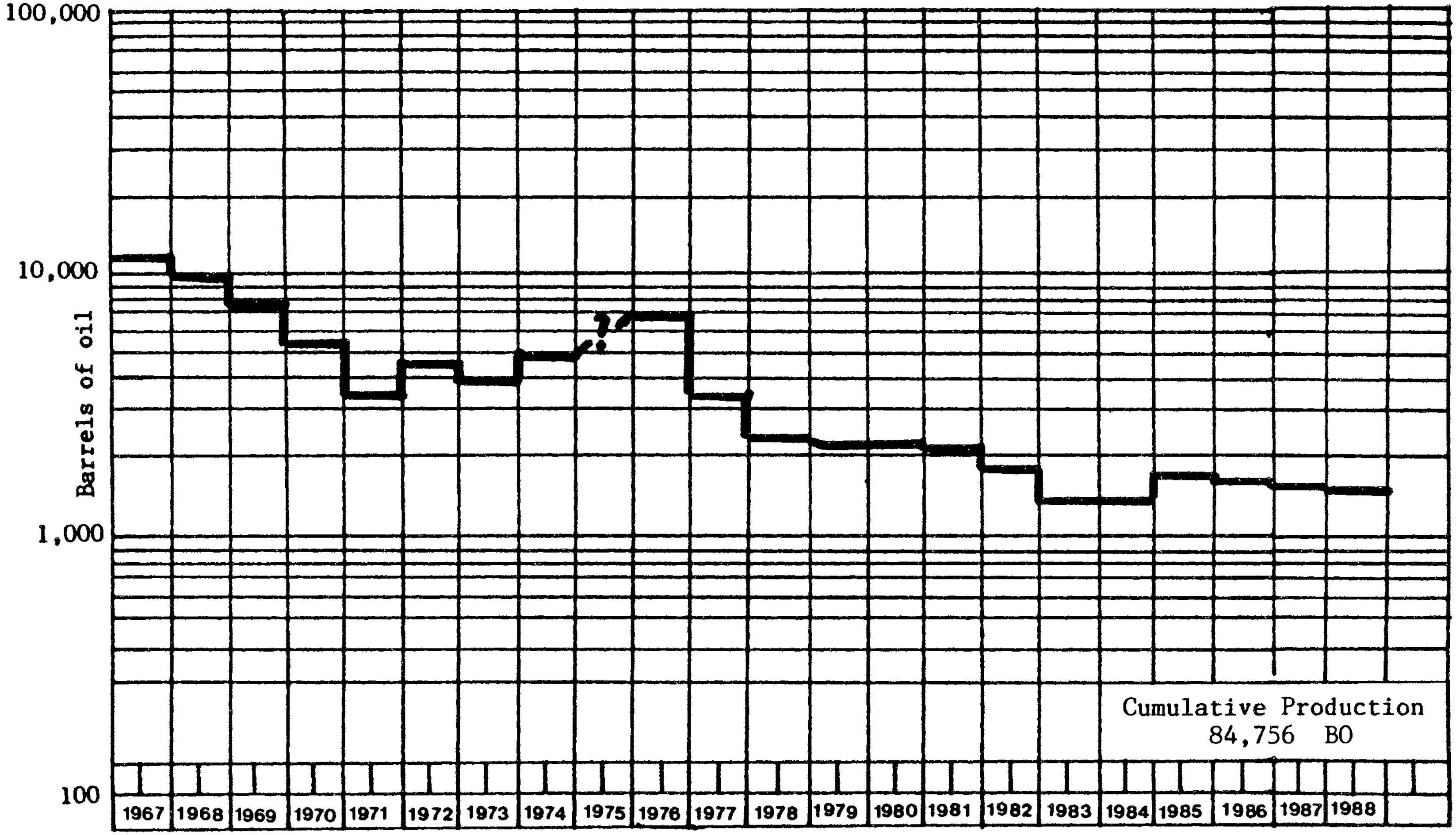

Figure 33. Production-decline Diagram, Osage-Layton Sandstone, Cushing Production Co., Stufflebeam No. 1, Section 3, T17N, R5E, NW NE NW, Cushing Townsite Field

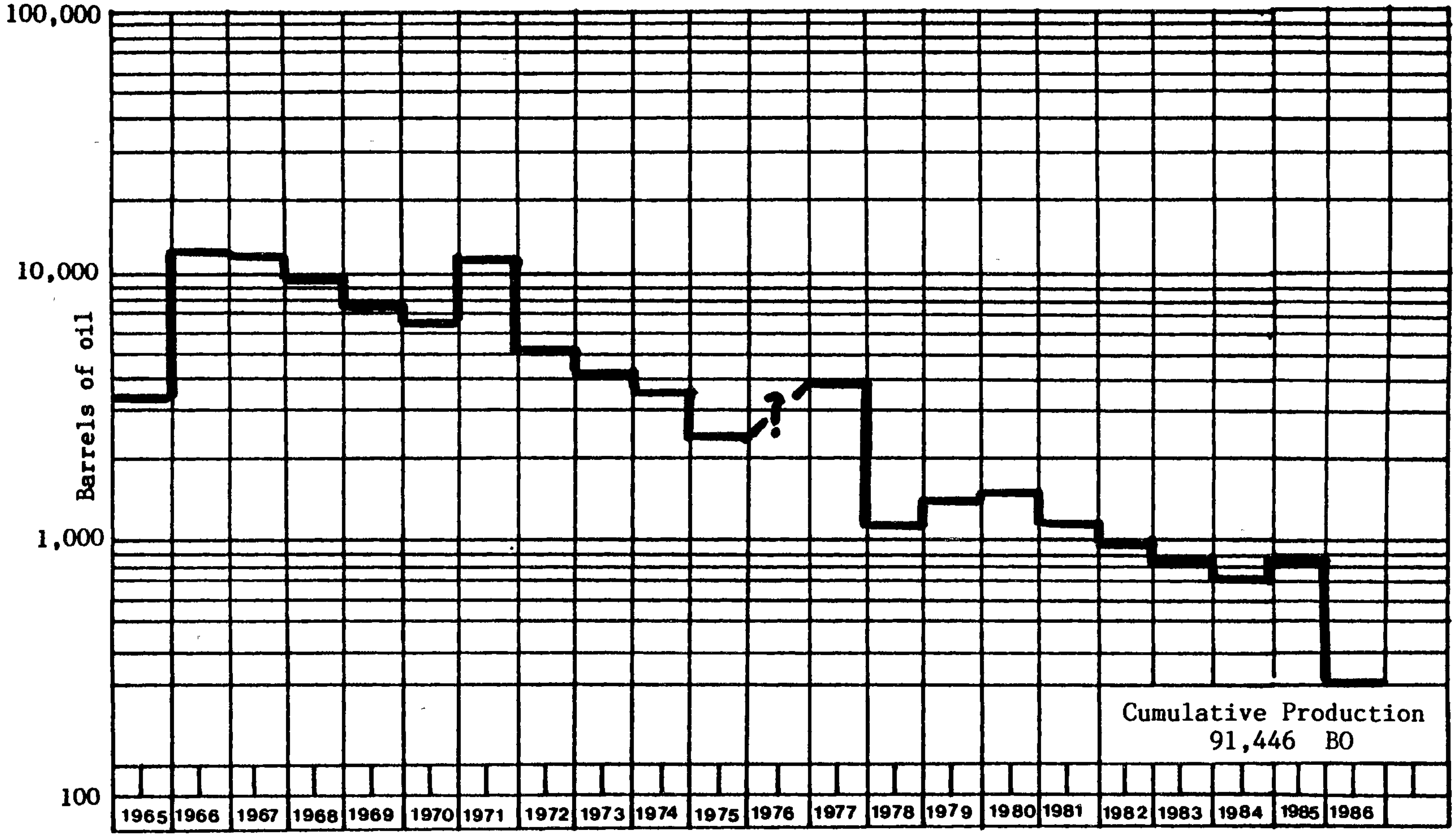

Figure 34. Production-decline Diagram, Osage-Layton Sandstone, J.M. Thompson, CO-OP No. 1, Section 34, T18N, R5E, SW SE SW, Cushing Townsite Field

CHAPTER VIII

CONCLUSIONS

Principal conclusions of this study are as follows:

1. The Osage-Layton sandstone interval overlies the Dewey Limestone, but at some localities in the study area the Dewey is absent and the Osage-Layton sandstone overlies the Nellie Bly Formation.

2. The Loula marker bed overlies the Osage-Layton sandstone interval, generally throughout the study area.

3. Three major structural trends are recognizable in the study area: northwest-southeast, northeast-southwest, and east-west.

4. Structural geological maps of the tops of the Loula limestone, Hogshooter Limestone, and Checkerboard Limestone show that regional dip is westward at about 65 ft./mi. The structural features that modify this homocline are plunging anticlinal and synclinal noses, anticlines, and normal faults.

5. The isopach map of the interval between the top of the Checkerboard Limestone and the top of the Hogshooter Limestone shows that the "True" Layton stratigraphic interval varies in thickness from 400 ft. in the

northeastern part of the study area (T19N-R5E) to less than 270 ft. in the southwestern part (T17N-R3E).

6. Several anomalous "thicks" and "thins" occur in the "True" Layton interval. These exceptional variations in thickness may be results of differential compaction above and around thick bodies of sandstone, they may reflect paleotopographic features that existed during the time the "True" Layton interval was deposited, or they may be combinations of the above.

7. The "True" Layton sandstone is silty to very fine grained, subrounded, and moderate to well sorted sublitharenite.

8. Detrital constituents of the "True" Layton sandstone are quartz, orthoclase, chert, feldspar, albite, muscovite, glauconite, and rock fragments of shale, siderite, and siltstone.

9. Diagenetic constituents of the "True" Layton sandstone are calcite cement, quartz overgrowths, and authigenic chlorite, illite, and kaolinite.

10. The isopach map of the interval between the top of the Hogshooter Limestone and the top of the Loula limestone shows that the Osage-Layton stratigraphic interval varies in thickness from 450 ft. in the southeastern part of the study area to less than 280 ft. in the northwestern part. This indicates that the source of the Osage-Layton sediments within the study area was to the southeast.

11. Several anomalous "thicks" and "thins" in the Osage-Layton interval are considered to have originated from processes described above, in relation to the "True" Layton sandstone.

12. The lower portion of the Osage-Layton sandstone grades into shale eastward and southeastward.

13. The Osage-Layton sandstone is silty to very fine grained, subangular to subrounded, and moderately sorted to well sorted.

14. Detrital constituents of the Osage-Layton sandstone are quartz, feldspar, metamorphic, rock fragments, muscovite, and zircon.

15. Principal diagenetic constituents of the Osage-Layton sandstone are pyrite, calcite cement, and quartz overgrowths.

16. Petroleum traps in the "True" Layton sandstone are combination stratigraphic and structural. Traps in the Norfolk and N. March fields are developed where the "True" Layton sandstone is folded over domal structures. At the Sporn field, petroleum is trapped where the "True" Layton sandstone pinches out updip.

17. Traps in the Osage-Layton sandstone are combination stratigraphic and structural traps, and they occur where thick bodies of sandstone are well developed within 80 ft. below the Loula limestone.

18. The petroleum trap for the northern part of the Broyles field occurs where the Osage-Layton sandstone

pinches out on an anticlinal nose. Petroleum traps in the southern part of the Broyles field, the N.E. Mehan, S. Broyles, March, Cushing Townsite, and Norfolk fields are positioned where the upper part of the Osage-Layton sandstone is folded entirely over domal structures.

19. A combination of log-signature maps, net-sand isopach maps of sandstone within 80 ft. below the Loula marker bed, and structural contour maps of the Loula limestone should be the best mapping technique to locate undrilled petroleum traps in the Osage-Layton sandstone.

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APPENDIXES

APPENDIX A

WELLS USED TO CONSTRUCT THE TYPE WIRELINE LOG

1) "Big" Limestone to Hogshooter Limestone Interval
Fullerton Oil Co.
Ezra Long Etux No. 1
Section 28, T19N, R4E
NE SW SW

2) Hogshooter Limestone to Loula Limestone Interval
Russell and Nelley
Dora Penny No. 1
Section 13, T19N, R4E
SE NE NW

3) Loula Limestone to Perry Gas Sand Interval
J.E. Crosbie Inc.
Myatt No. B-2
Section 25, T19N, R4E
SE SW NW

APPENDIX B

DESCRIPTION OF BIT CUTTINGS, MAGNUM ENERGY INC., NANCY NO. 1, SEC. 7, T19N, R5E, SE SW SE

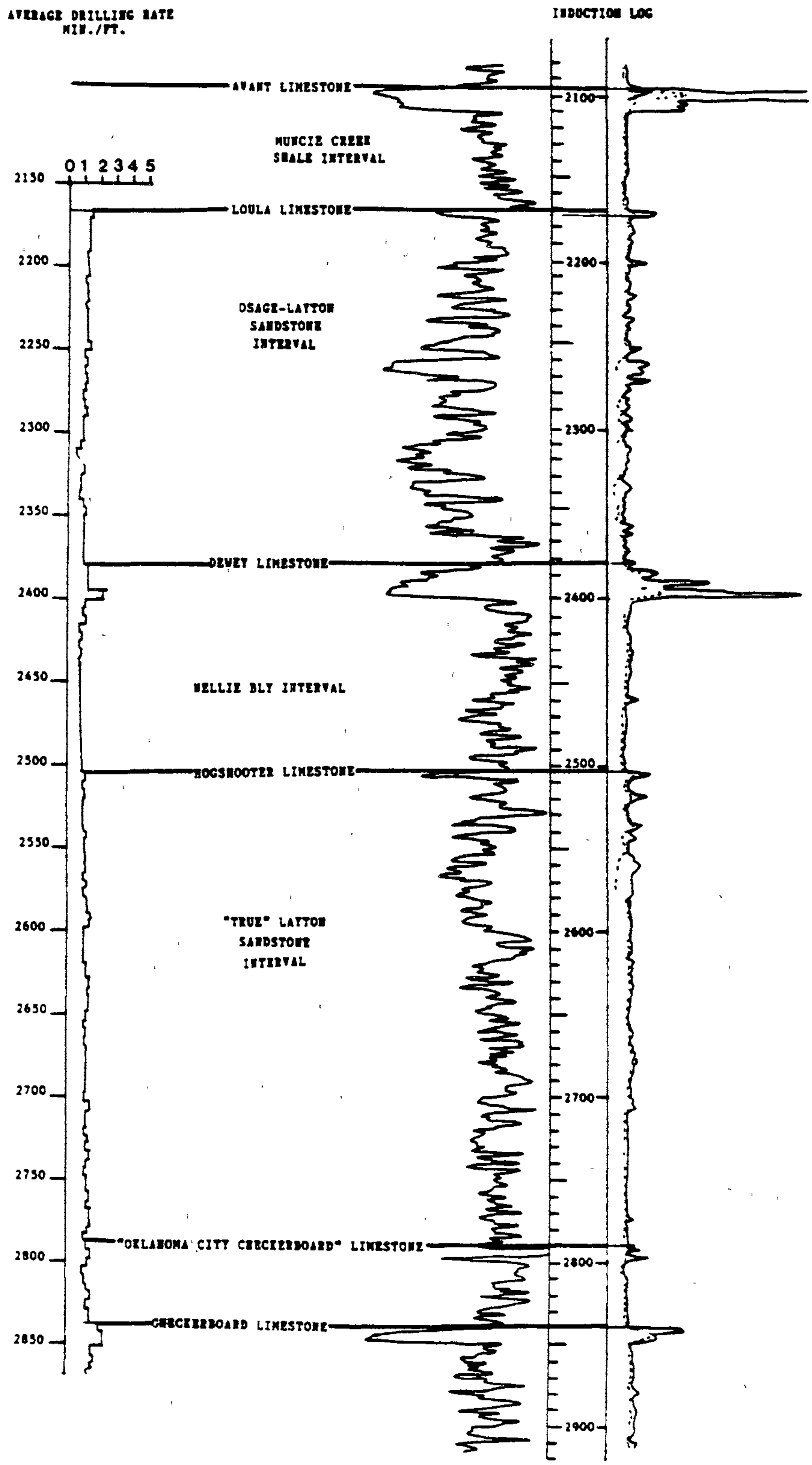


Figure 35. Correlation of the Drilling Time Rate to the Induction Log, Magnum Energy Inc., Nancy No. 1, Sec. 7, T19N, R5E, SE SW SE.

Magnum Energy Inc., Nancy No. 1, Sec. 7, T19N, R5E, SE SW SE.

Bit Cuttings Interval: Base Perry Gas Sand Interval to the Base of the Checkerboard Limestone.

Correlation: Interpretive Description of Bit Cuttings

Log Depth (Ft.)	Description of Bit Cuttings
	Base Perry Gas Sand (Shale)
2070 - 2090	Shale, light gray, fissile, slightly silty, micaceous, slightly carbonaceous, and fossiliferous.
	Avant Limestone
2090 - 2107	Sandy limestone, white to pale yellow brown, coarsely crystalline, with fine-grained sand, pyritic, vuggy, and dolomitic.
	Muncie Creek Shale
2107 - 2166	Shale, silty, dark greenish gray, fissile, micaceous, calcareous cement, waxy, and fossiliferous.
	Loula Limestone
2166 - 2174	Limestone, silty, brownish gray, bioclastic, and coarsely crystalline.
	Osage-Layton Sandstone Interval
2174 - 2195	Shale, silty, light brown, fissile, and micaceous.
2195 - 2257	Interbedded sandstone and shale Sandstone: Very light gray to light gray, silty to very fine grained, micaceous, carbonaceous, pyritic, with clayey matrix and dense green and black fragments. Shale: Medium gray to grayish black, micaceous, fissile, "greasy", orange-brown spheroids in shale; pyritic, and fossiliferous.

2257 - 2271	Sandstone, transparent to white, fine grained, slightly micaceous, calcareous, clayey matrix; quartz overgrowths; dense green and black fragments.
2271 - 2276	Sandy limestone, orange-red, coarsely crystalline, very fine grained sand; pyritic.
2276 - 2295	Interbedded sandstone and shale Sandstone: "Salt-and-pepper" to light gray, silty to very fine grained, micaceous, clayey matrix, carbonaceous, calcareous, with dense black and green fragments. Shale: Grayish green, micaceous, fissile.
2295 - 2306	Limestone, white to tan, chalky, soft, micaceous; with dense black fragments.
2306 - 2324	Sandstone, transparent to white, fine grained, slightly micaceous, calcareous, clayey matrix, quartz overgrowths; with dense black and green fragments.
2324 - 2328	Shale, grayish green, micaceous, fissile, and calcareous.
2328 - 2340	Sandstone, transparent to white, fine grained, slightly micaceous, calcareous, clayey matrix, quartz overgrowths; dense black and green fragments.
2340 - 2380	Interbedded sandstone and shale Sandstone: "Salt-and-pepper" to light gray, silty to very fine grained, micaceous, clayey matrix, carbonaceous, calcareous; with dense black and green fragments. Shale: Grayish green, micaceous, and fissile.
	<u>Dewey Limestone</u>
2380 - 2396	Sandy limestone, yellow-brown to orange-brown, very fine grained, mottled.
2396 - 2403	Limestone, tan, massive, coarsely crystalline, micaceous.

	<u>Nellie Bly Interval</u>
2403 - 2505	Interbedded sandstone, siltstone, shale, and limestone. Sandstone: Brownish gray, silty to very fine grained, very micaceous, dense black and green clasts, very dirty clayey appearance, crystalline quartz overgrowths, pyritic; quartz is transparent and colorless to smoky gray, calcareous, carbonaceous; some red particles. Shale: Gray to dark gray, fissile, micaceous, fossiliferous, very pyritic (pyrite associated with fossils), silty; dense black and green clasts. Siltstone: Light gray, micaceous, clayey matrix, carbonaceous; with black, green and red particles. Limestone: Tan, very fossiliferous, mottled.
	<u>Hogshooter Limestone</u>
2505 - 2510	Limestone, white to tan, soft to hard, chalky, pyritic, very fossiliferous.
	<u>"True" Layton Sandstone Interval</u>
2510 - 2520	Sandstone, gray, very fine grained, very carbonaceous, micaceous, dirty clayey appearance, dense black and green clasts, quartz overgrowths, calcite cement, pyritic.
2520 - 2526	Limestone, white to tan, soft, chalky.
2526 - 2612	Interbedded sandstone and shale Sandstone: Gray, very fine grained carbonaceous, micaceous, dirty clayey appearance, quartz overgrowths, calcite cement, pyritic; dense black and green clasts. Shale: Gray to dark gray, silty, fissile, pyritic, "greasy", fossiliferous
2612 - 2677	Interbedded sandstone and shale. Sandstone: Gray, very fine grained, carbonaceous, micaceous, dirty

	clayey appearnace, quartz overgrowths, calcite cement, pyritic; with dense black and green clasts. Shale: Gray to dark gray, silty, fissile, pyritic, "greasy", fossiliferous.
2677 - 2690	Sandy limestone, tan, carbonaceous, dolomitic, silty to very fine grained sand, micaceous; with dense green and black particles.
2690 - 2703	Sandstone, light gray to gray, silty to very fine grained, very micaceous, very carbonaceous, with dirty clayey appearance.
2703 - 2711	Limestone, pinkish white, compact, slightly crystalline, mottled.
2711 - 2735	Sandstone, silty to very fine grained, light gray to gray, very micaceous, very carbonaceous, with dirty clayey appearance.
2735 - 2774	Interbedded siltstone and shale Siltstone: Light brown to gray, quartz overgrowths, compact, slightly carbonaceous, slightly micaceous, with dense black and green fragments. Shale: Gray to dark gray, silty, fissile, pyritic, "greasy," fossiliferous.
2774 - 2778	Sandy limestone, very pale orange, silty to very fine grained sand, crystalline, with dense black and red grains.
2778 - 2793	Interbedded siltstone and shale Siltstone: Light gray, very micaceous, carbonaceous, soft, very friable; with calcite cement and dense black, green, and orange grains. Shale: Gray to dark gray, silty, fissile, pyritic, "greasy," fossiliferous.

"Oklahoma City Checkerboard" Limestone

2793 - 2796	Limestone, moderate brown, dense, and fossiliferous.
2796 - 2802	Limestone, white to tan, soft, and fossiliferous.

Interval between "Oklahoma City Checkerboard" Limestone and the Checkerboard Limestone

2802 - 2843	Interbedded siltstone and shale Siltstone: Light gray, micaceous, carbonaceous, soft, friable; with calcite cement and dense black and green minerals. Shale: Gray, waxy, micaceous, pyritic, fissile, fossiliferous.

Checkerboard Limestone

2843 - 2853	Limestone, off-white to tan, soft, crystalline, and chalky.

APPENDIX C

X-RAY DIFFRACTION PATTERNS, PETROLOGIC LOG,

AND PHOTOGRAPH OF CORE OF "TRUE" LAYTON

SANDSTONE, GRACE PETROLEUM CORP.,

BAIR NO. 1, SEC. 12, T17N,

R7E, 100 FT. S NW NW SW

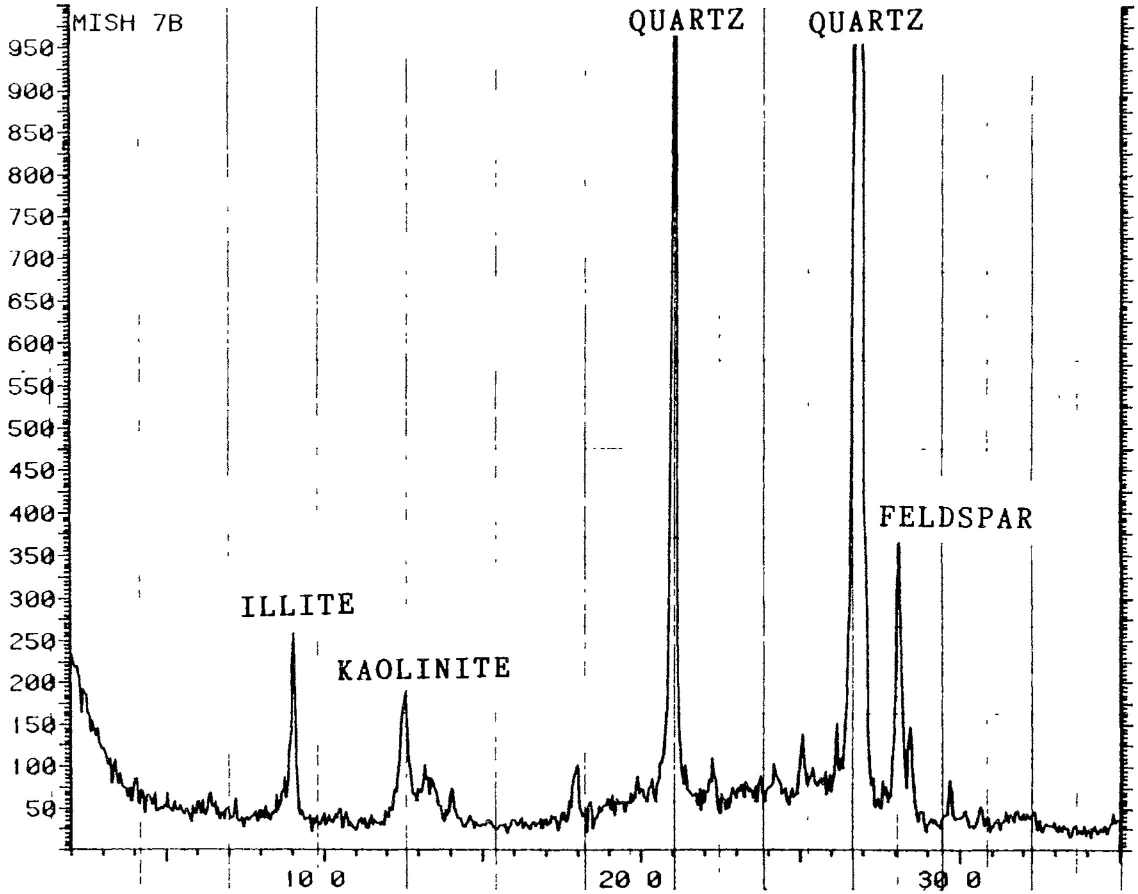


Figure 36. X-ray Diffraction Pattern 7B, "True" Layton Sandstone, Grace Petroleum Corp., Bair No. 1, Sec. 12, T17N, R7E, 100 FT. S NW NW SW.

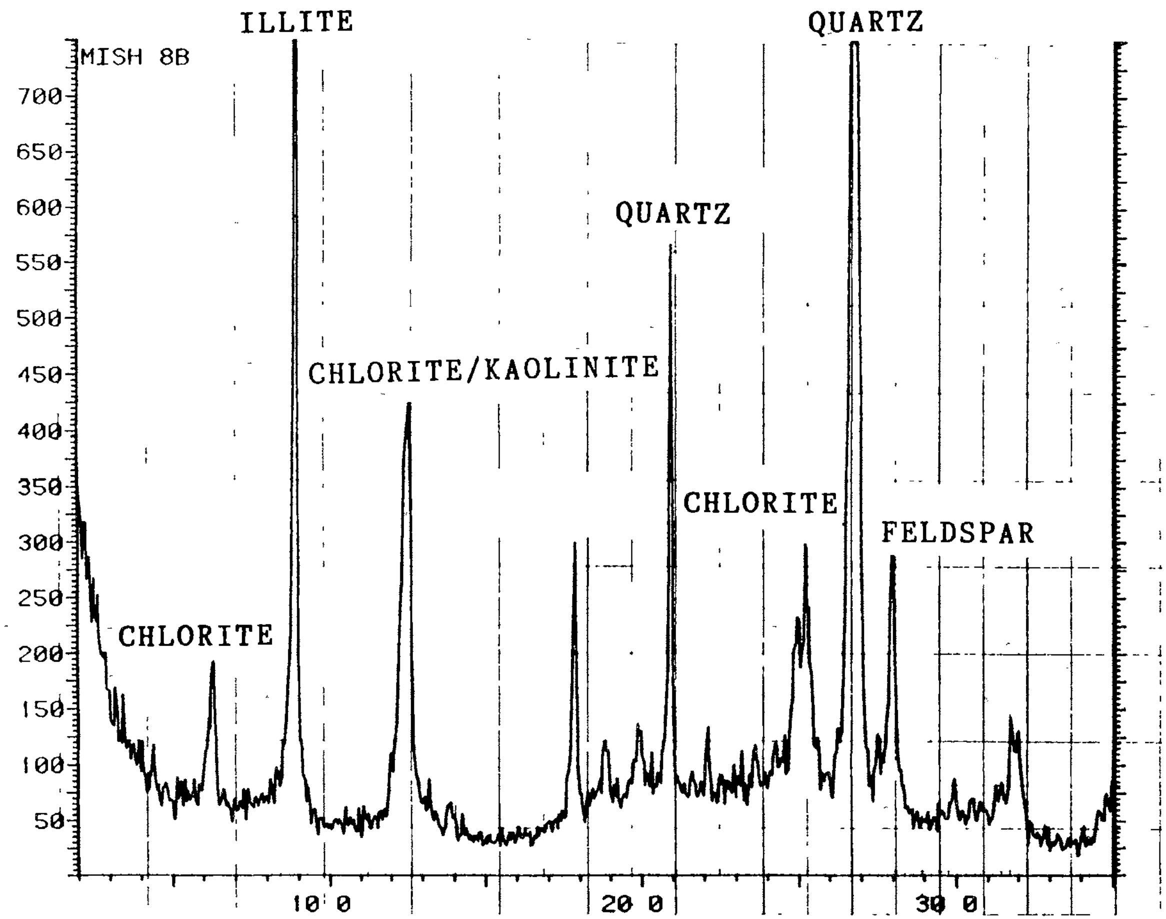


Figure 37. X-ray Diffraction Pattern 8B, "True" Layton Petroleum Sandstone, Grace Corp., Bair No. 1, Sec. 12, T17N, R7E, 100 FT. S NW NW SW.

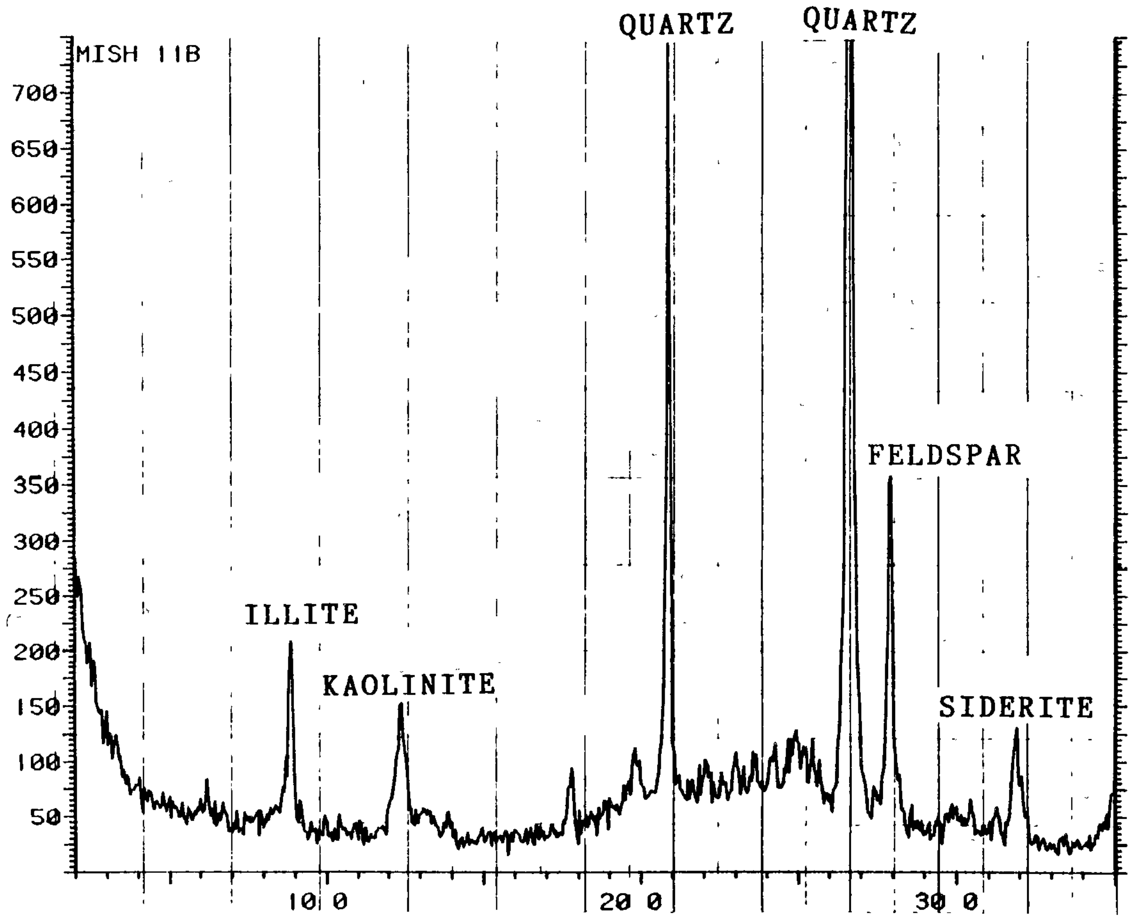


Figure 38. X-ray Diffraction Pattern 11B, "True" Layton Sandstone, Grace Petroleum Corp., Bair No. 1, Sec. 12, T17N, R7E, 100 FT. S NW NW SW.

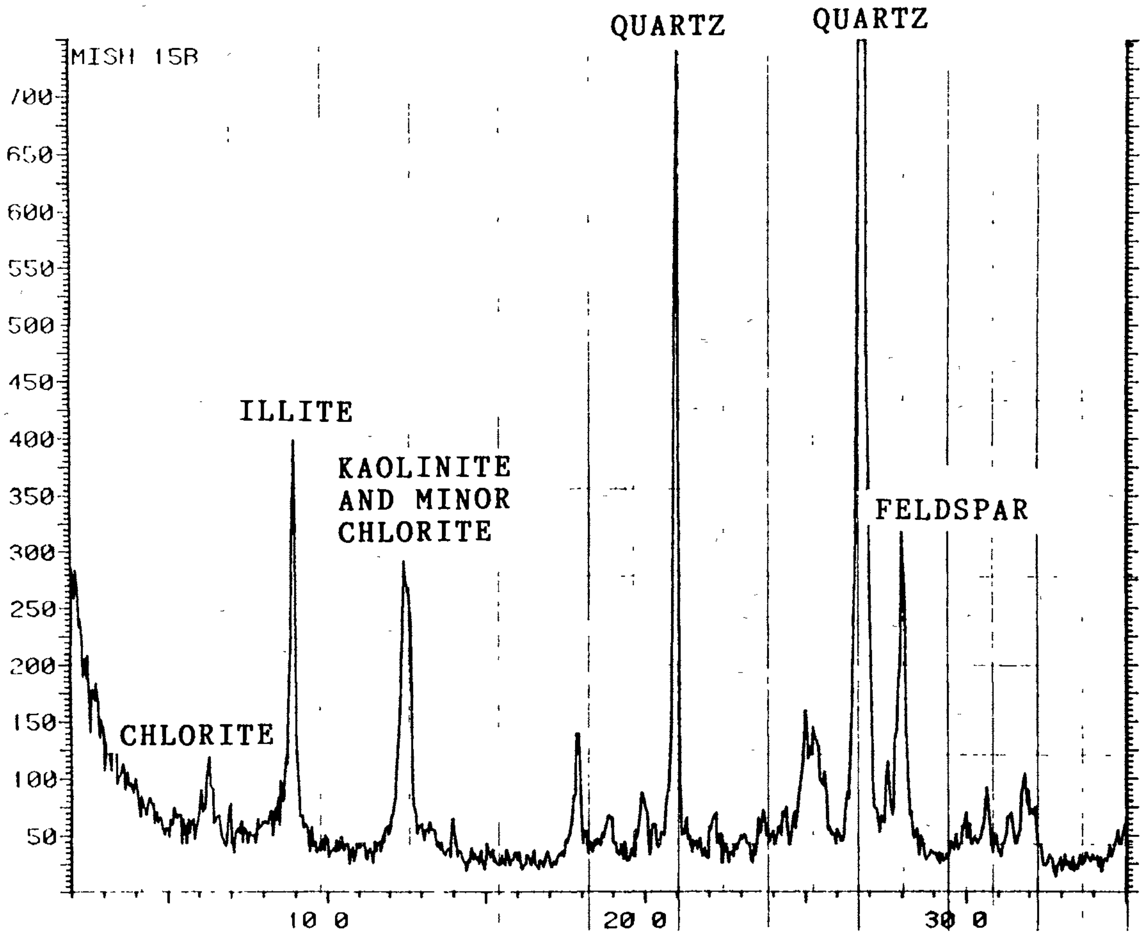


Figure 39. X-ray Diffraction Pattern 15B, "True" Layton Sandstone, Grace Petroleum Corp., Bair No. 1, Sec. 12, T17N, R7E, 100 FT. S NW NW SW.

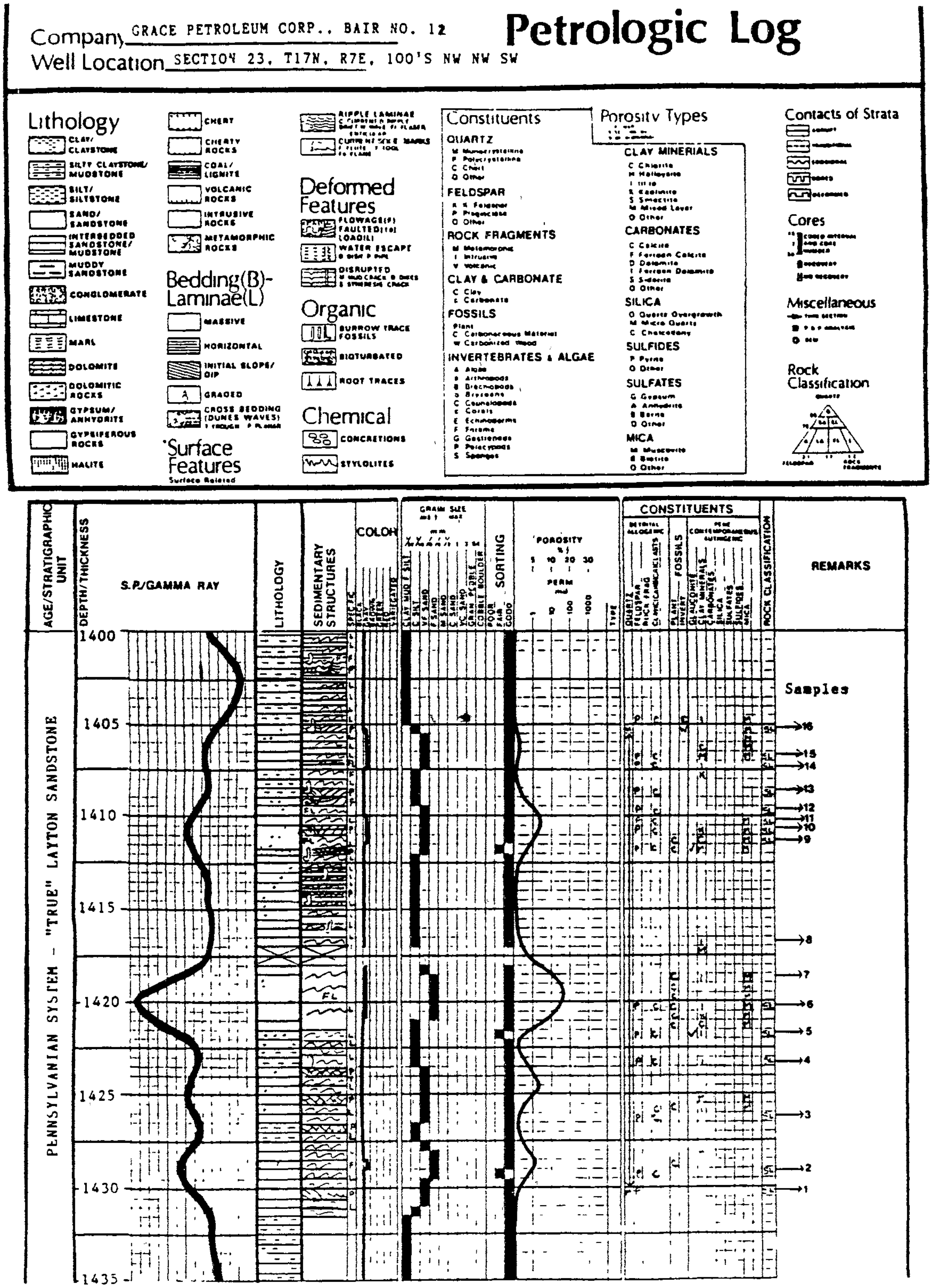


Figure 40. Petrologic Log, "True" Layton Sandstone, Grace Petroleum Corp., Bair No. 12, Sec. 12, T17N, R7E, 100 FT. S NW NW SW.

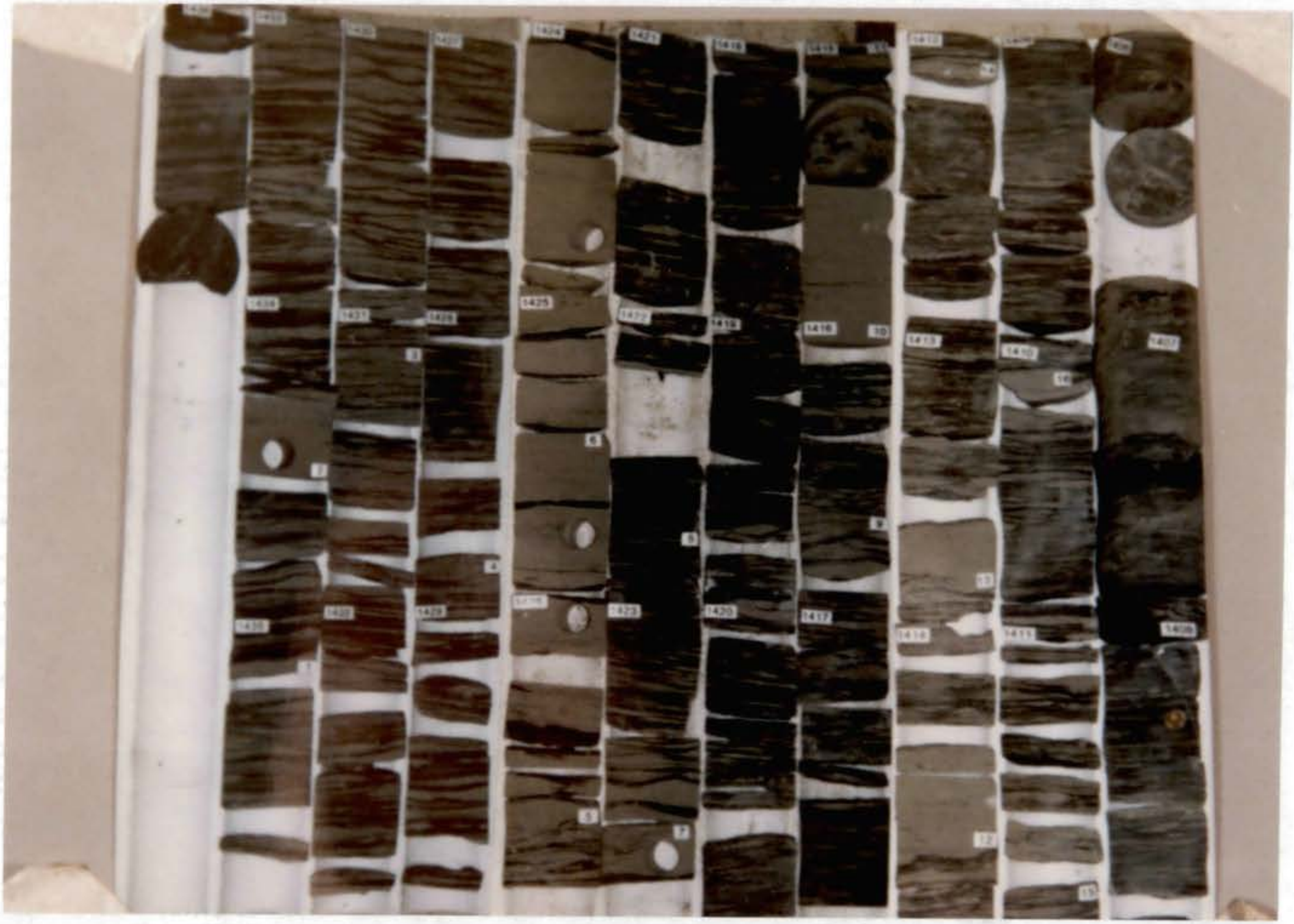


Figure 41. Core Photograph, "True" Layton Sandstone, Grace Petroleum Corp., Bair No. 1, Sec. 12, T17N, R7E, 100 FT. S NW NW SW. (Correlation: Core 5.2 FT. Lower Than Electric Log).

APPENDIX D

PRODUCTION DECLINE DIAGRAMS,

OSAGE-LAYTON SANDSTONE

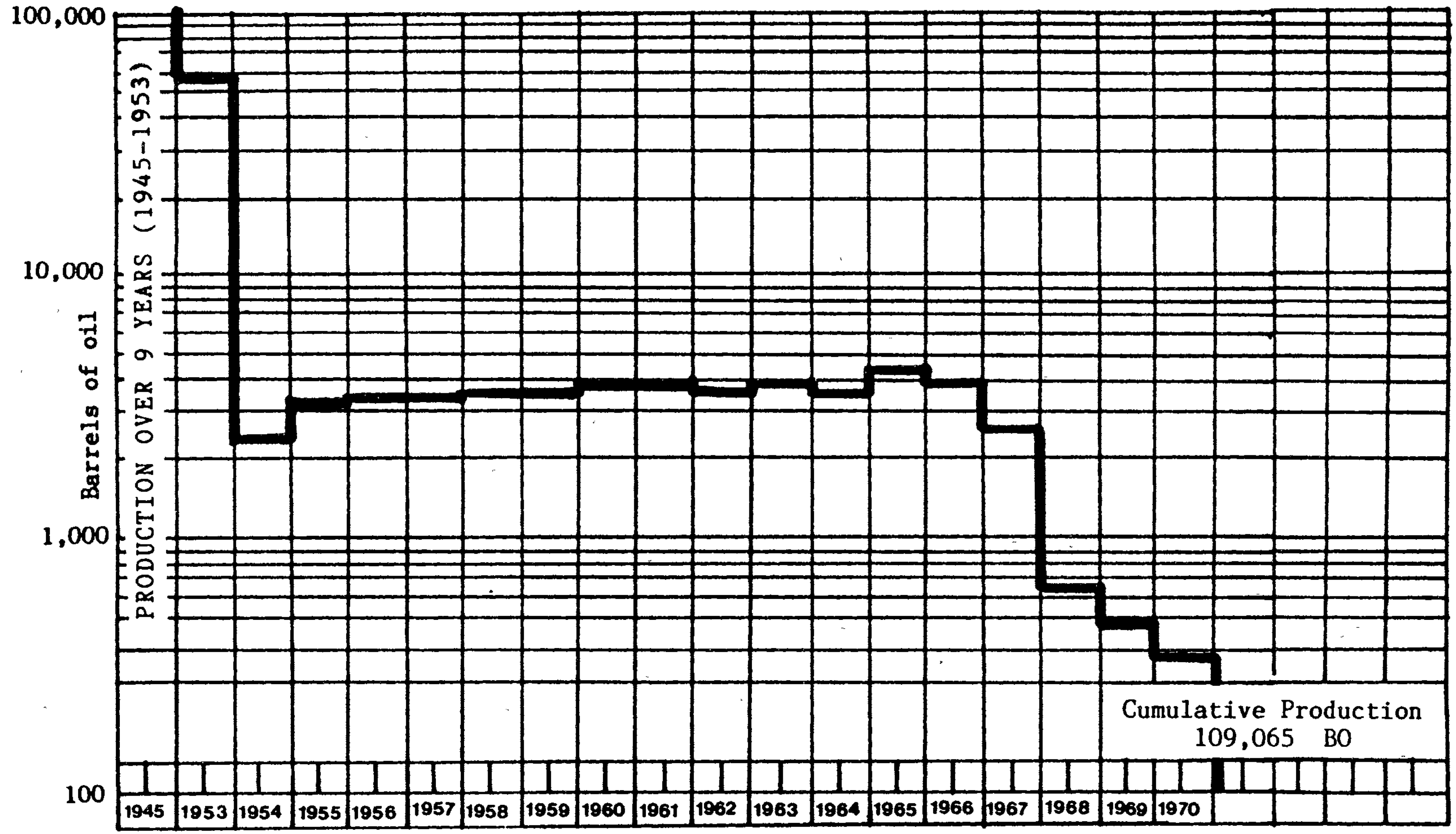


Figure 42. Production-decline Diagram, Osage-Layton Sandstone (Commingled Production from 2 Wells). (1) T.N. Berry, Thompson No. 1, Sec. 24, T18N, R4E, SW SW NW. (2) T.N. Berry, Thompson No. 2, Sec. 24, T18N, R4E, SE SW NW. Northern Part, Broyles Field.

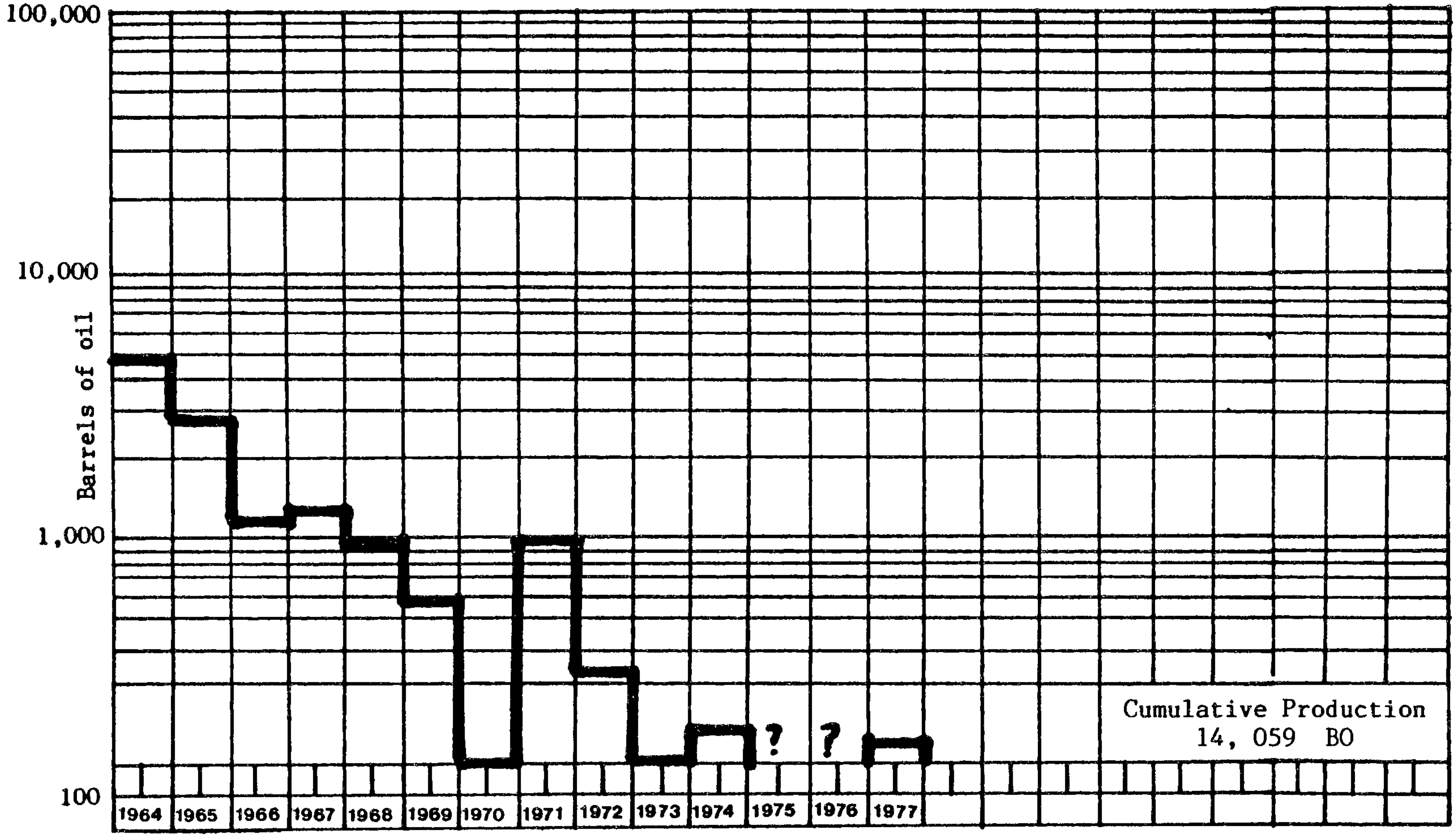


Figure. 43. Production-decline Diagram, Osage-Layton Sandstone. B.M. Heath et al., School Land No. 1, Sec. 36, T18N, R4E, SW SW NW, S. Broyles Field.

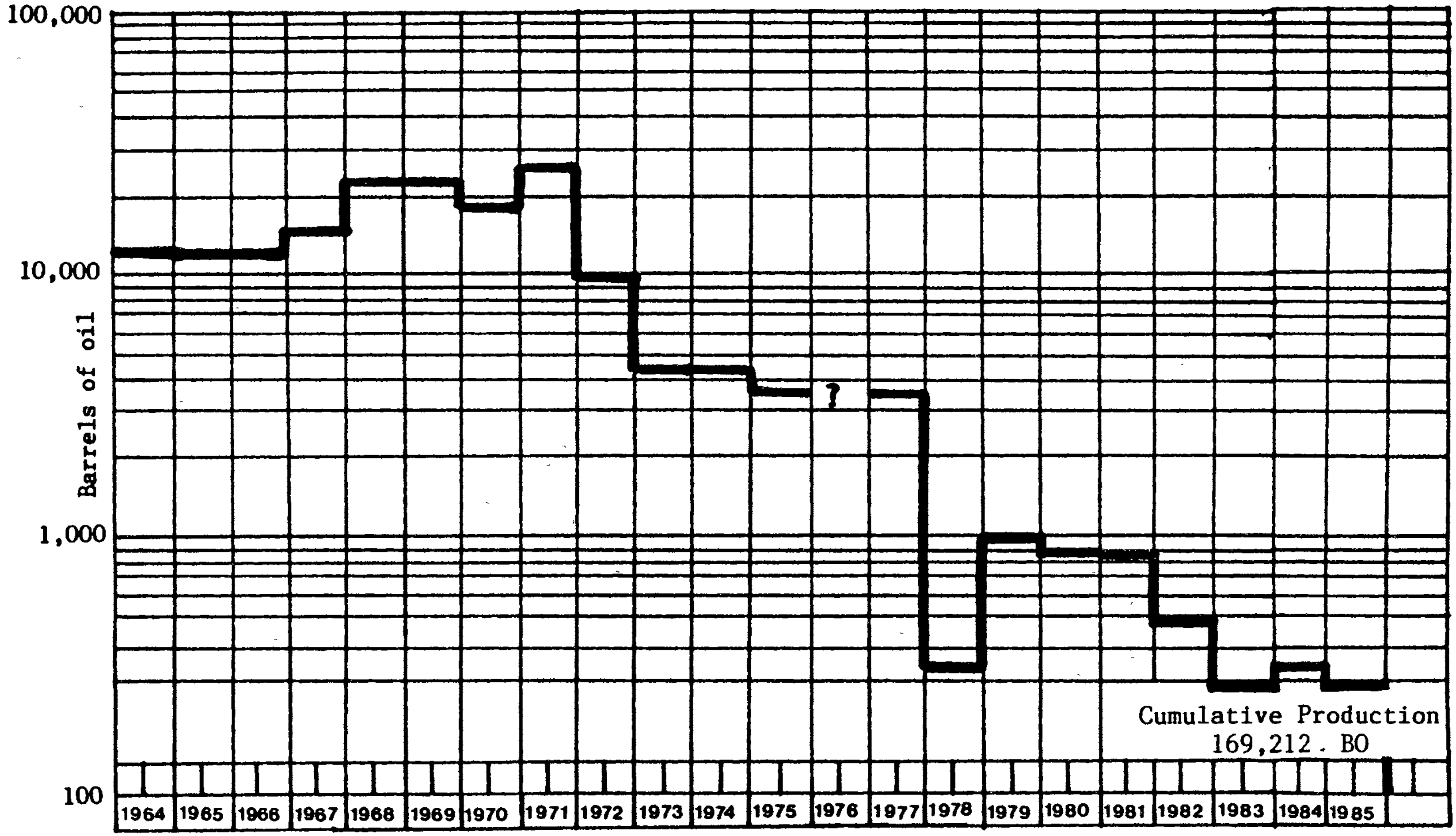


Figure 44. Production-decline Diagram, Osage-Layton Sandstone (Commingled Production from 3 Wells). S. Broyles Field. (1) B.M. Heath et al., Mandeville No. A-1, Sec. 35, T18N, R4E, NW NE SE. (2) B.M. Heath et al., Mandeville No. A-2, Sec. 35, T18N, R4E, SE NE SE. (3) B.M. Heath et al., Mandeville No. A-3, Sec. 5, T18N, R4E, NE SE SE.

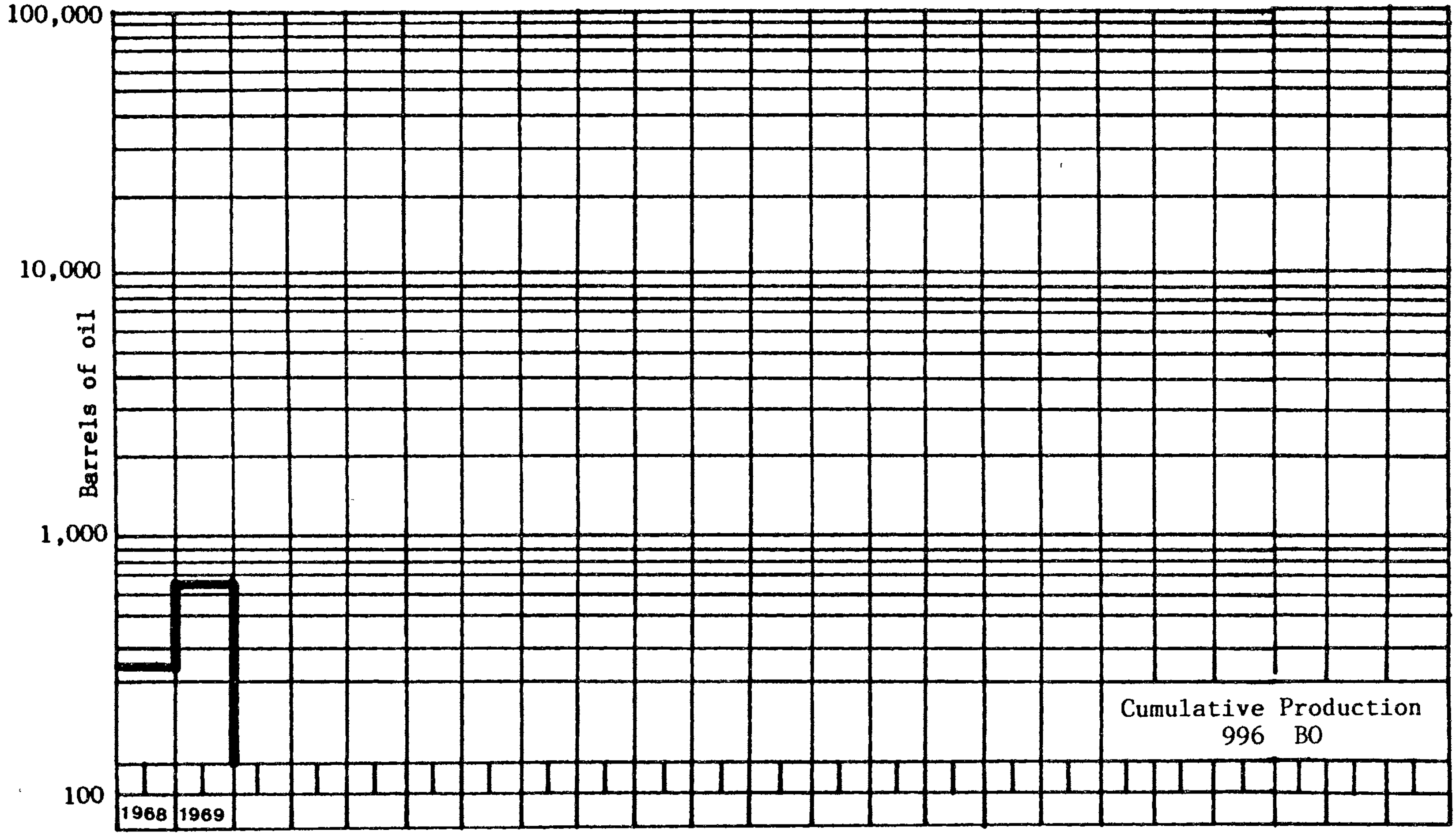


Figure 45. Production-decline Diagram, Osage-Layton Sandstone. Jon W. Beam, Gaunt No. 1, Sec. 15, T18N, R5E, SE SE NW, N.W. Gano Field.

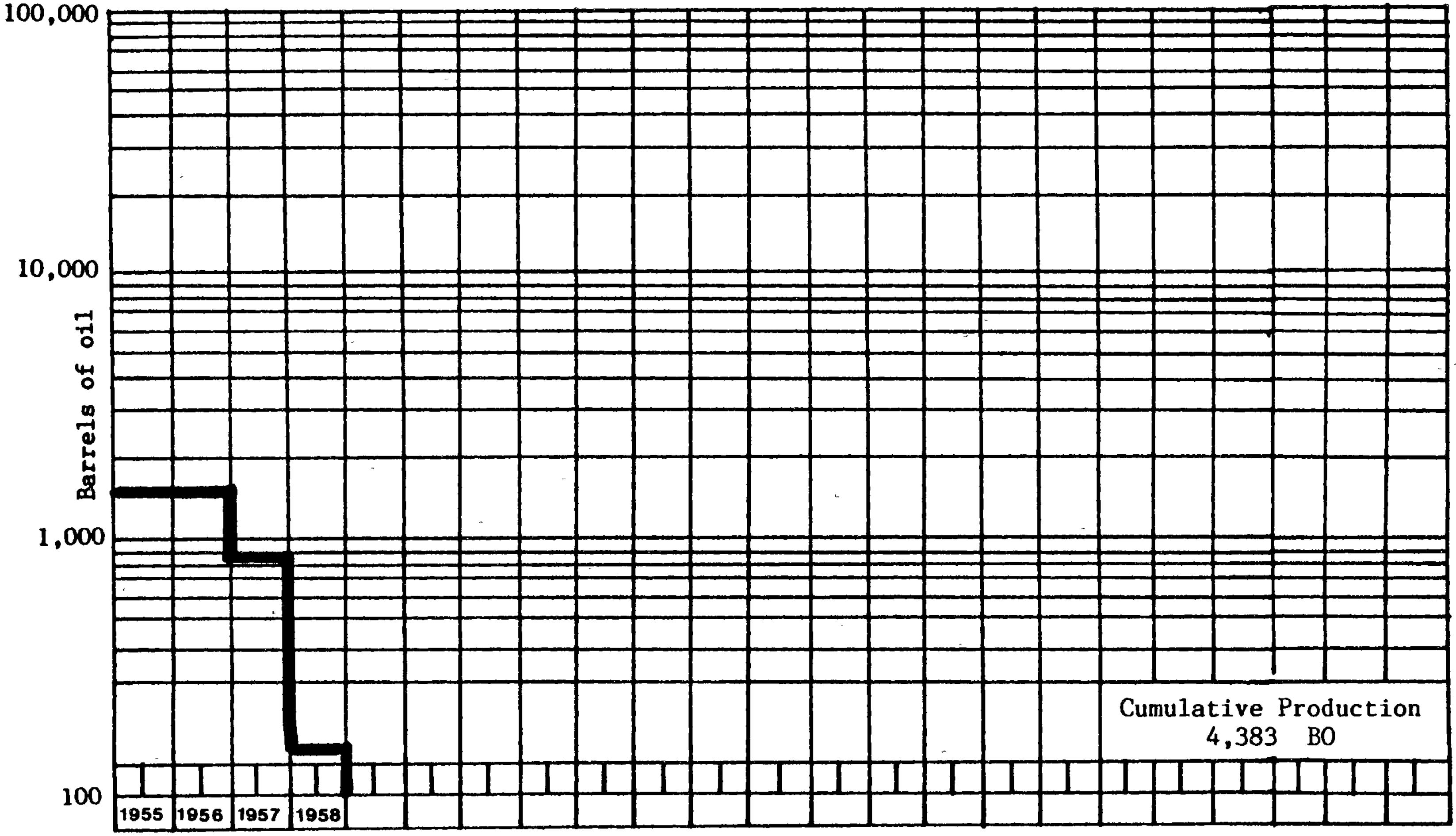


Figure 46. Production-decline Diagram, Osage-Layton Sandstone. Foster Drilling Co., Bernice No. 1, Sec. 30, T18N, R5E, SW SE NE, March Field.

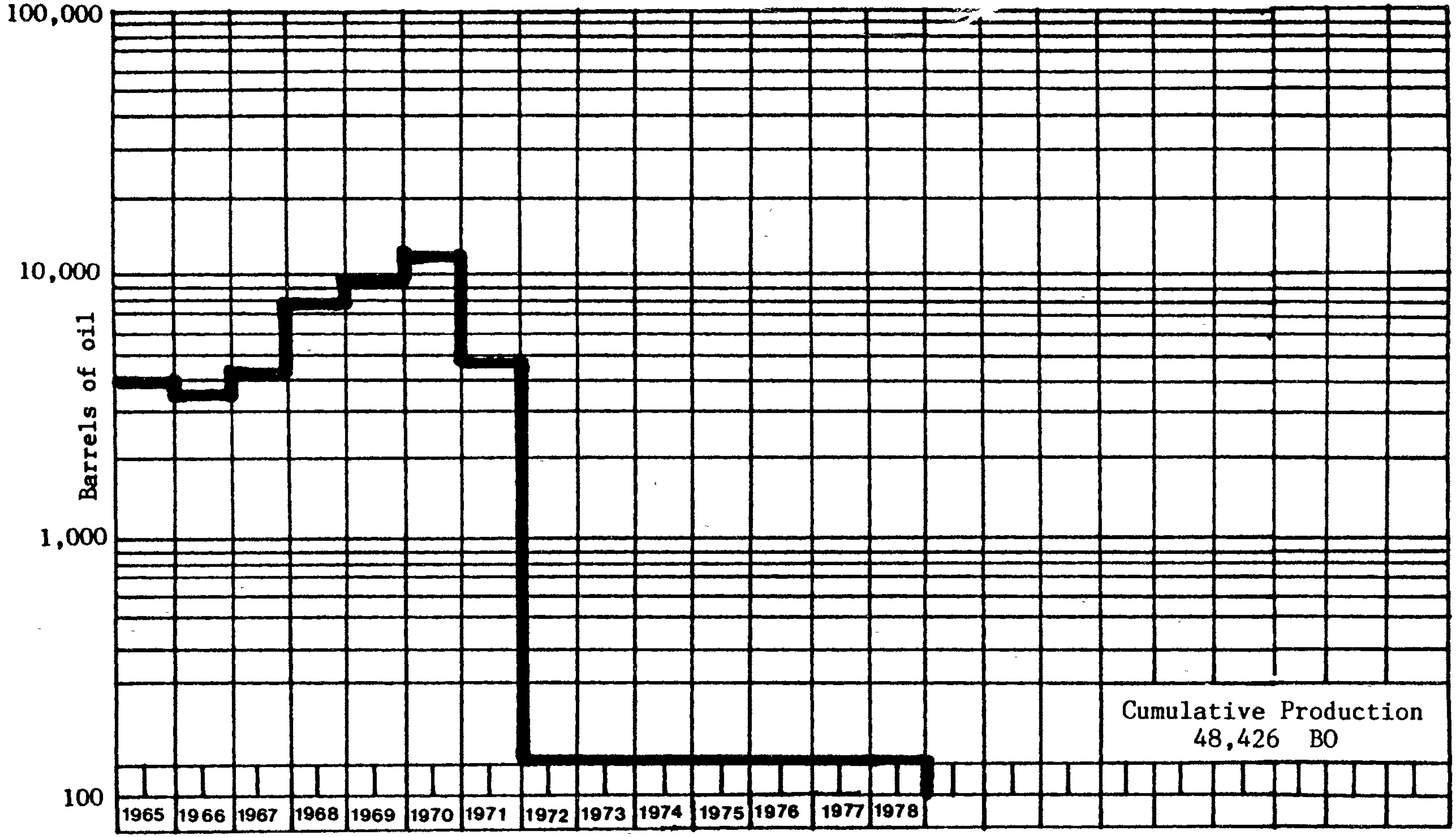


Figure 47. Production-decline Diagram, Osage-Layton Sandstone. Thomas E. Berry, Armento No. 1, Sec. 24, T18N, R5E, NE NE SW, Norfolk Field.

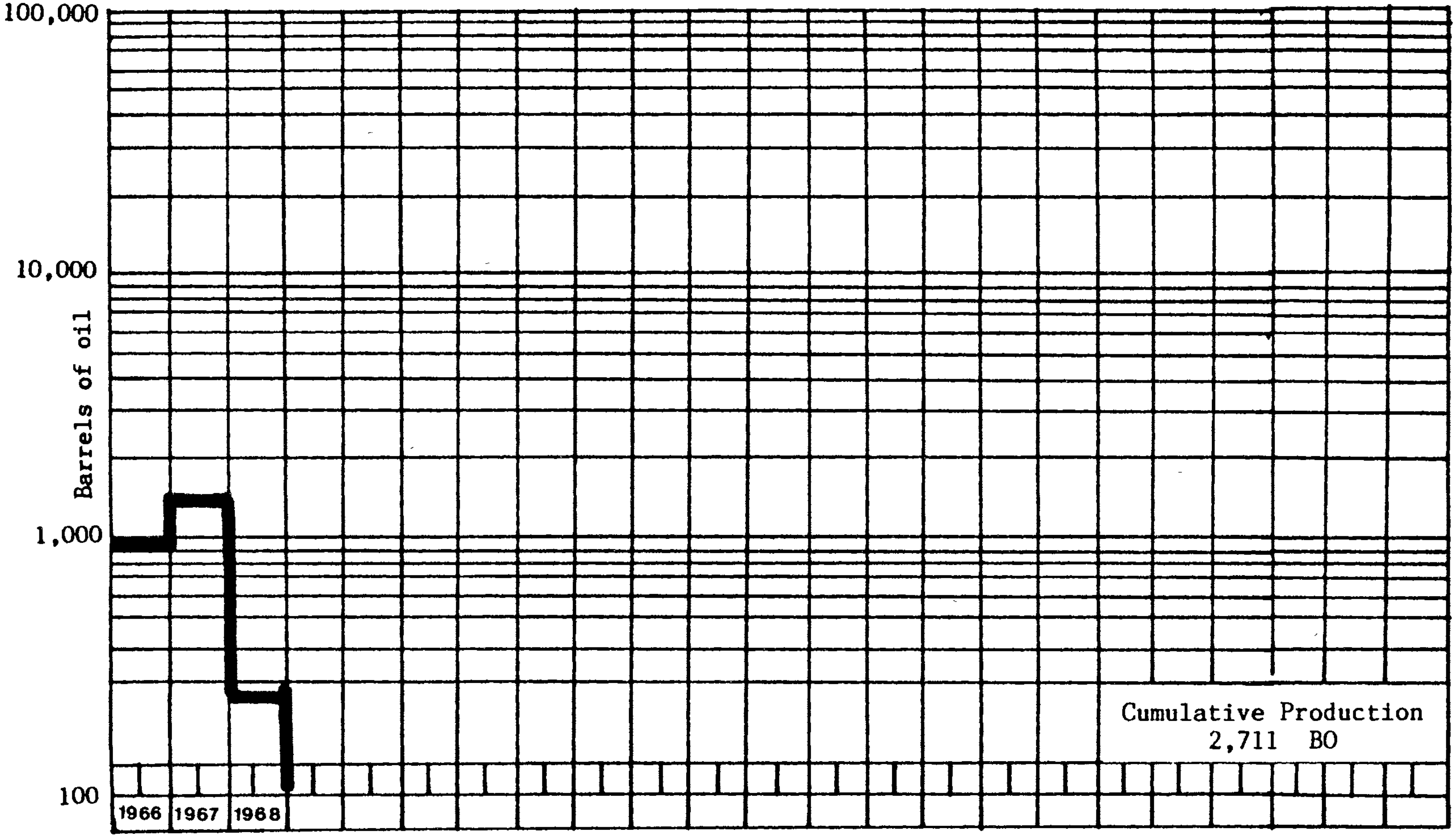


Figure 48. Production-decline Diagram, Osage-Layton Sandstone. Robinson and Brown, Dillman No. 1, Sec. 24, T18N R5E, NW SW SE, Norfolk Field.

VITA

Kelly L. Mish

Candidate for the Degree of

Master of Science

THESIS: THE OSAGE-LAYTON SANDSTONE AND THE "TRUE" LAYTON SANDSTONE, SOUTHERN PAYNE COUNTY, NORTHERN LINCOLN COUNTY, OKLAHOMA

Major Field: Geology

Biographical:

Personal Data: Born in Oklahoma City, Oklahoma, February 19, 1960, the daughter of Mr. and Mrs. Robert T. Mish.

Education: Graduated from LakeVille High School, Otisville, Michigan, in June, 1978; attended Michigan State University, September, 1978 to August, 1981; received Bachelor of Science degree in Geology from Oklahoma State University, Stillwater, Oklahoma, in May, 1985; completed requirements for the Master of Science degree at Oklahoma State University in May, 1989.

Professional Experience: Geological Technician, Lon B. Turk, Oklahoma City, Oklahoma, February, 1984 to July, 1984; Geological Technician, Thomas N. Berry and Company, Stillwater, Oklahoma, November, 1984 to August, 1987; Geological Technician, Kahan and Associates, Tulsa, Oklahoma, June, 1988 to February, 1989. Junior Member of the American Association of Petroleum Geologists.

PLATE 1

NORTH-SOUTH

STRATIGRAPHIC CROSS SECTION A-A'

NO HORIZONTAL SCALE

KELLY L. MISH 1989

PLATE 2

NORTH-SOUTH

STRATIGRAPHIC CROSS SECTION B-B'

NO HORIZONTAL SCALE

BY KELLY L. MISH 1989

PLATE 3
NORTH-SOUTH
STRATIGRAPHIC CROSS SECTION C-C'

NO HORIZONTAL SCALE

BY KELLY L. MISH 1989

PLATE 4

EAST-WEST

STRATIGRAPHIC CROSS SECTION D-D'

NO HORIZONTAL SCALE

BY KELLY L. MISH 1989

PLATE 5

EAST-WEST

STRATIGRAPHIC CROSS SECTION E-E'

NO HORIZONTAL SCALE

BY KELLY L. MISH 1989

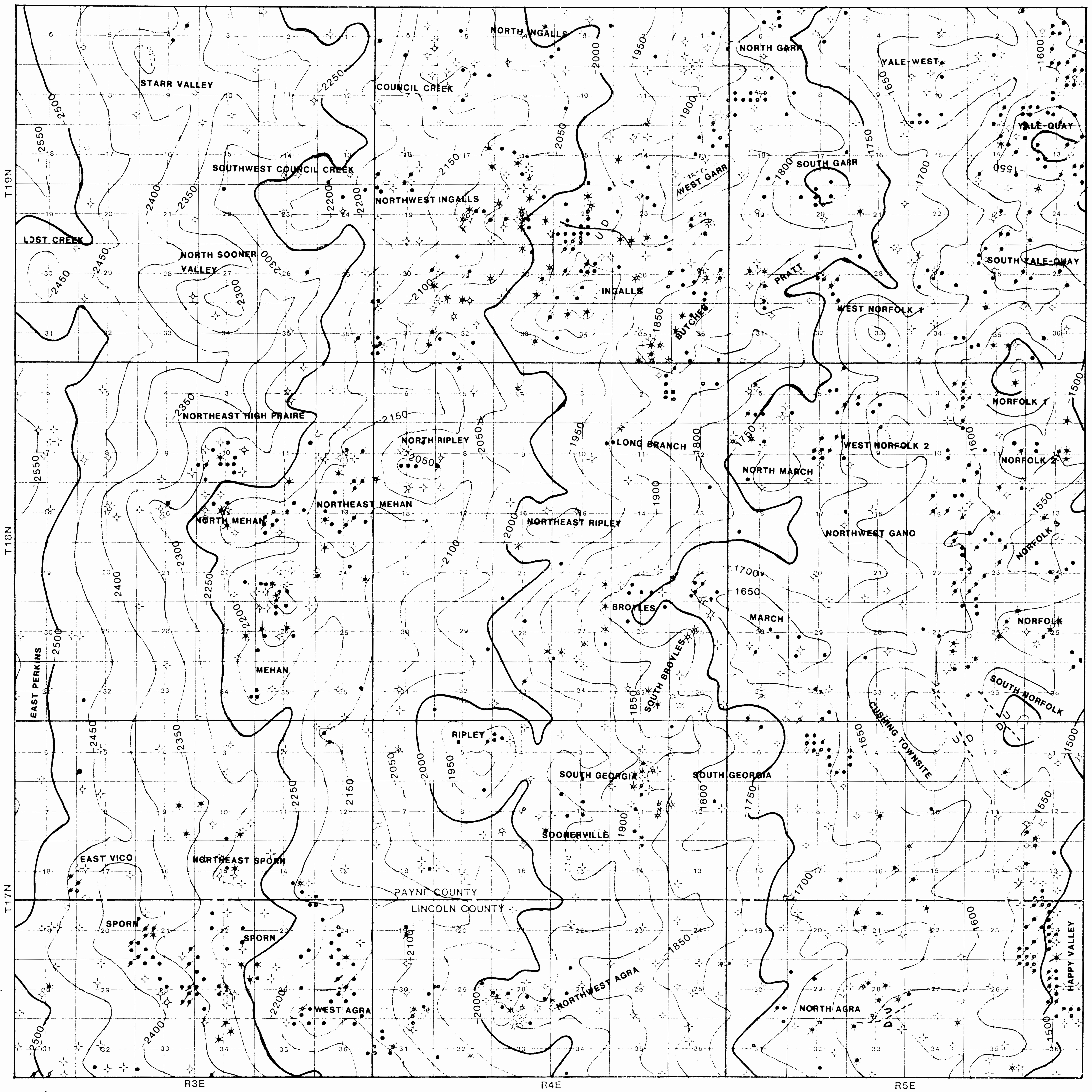
PLATE 6

EAST-WEST

STRATIGRAPHIC CROSS SECTION F-F'

NO HORIZONTAL SCALE

BY KELLY L. MISH 1989



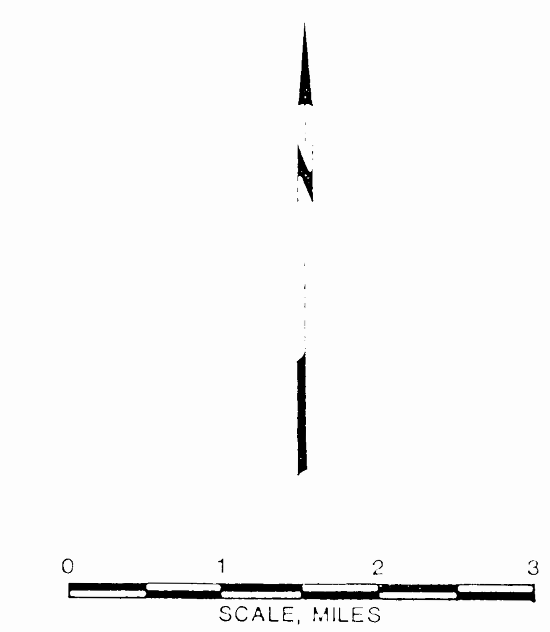


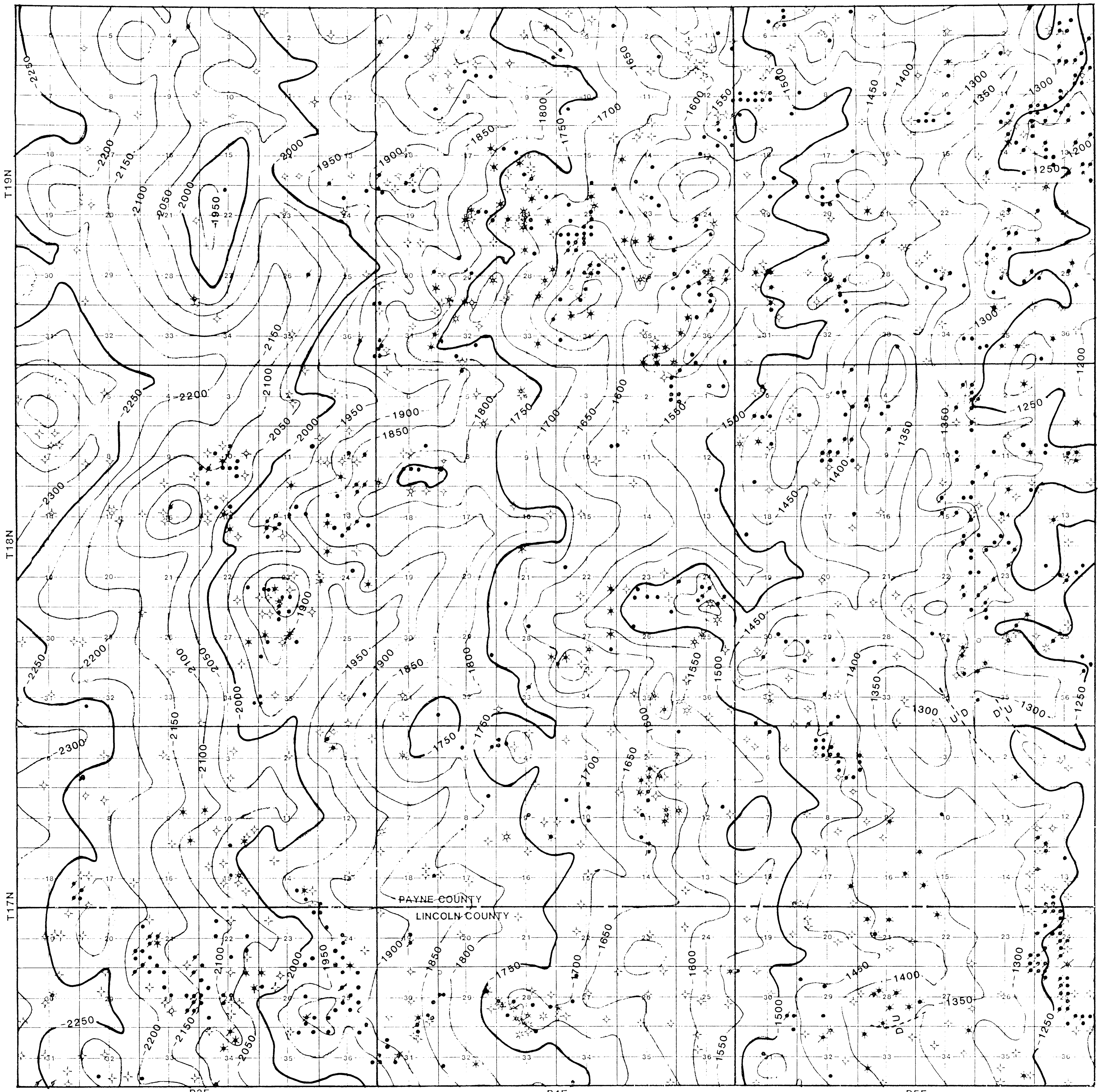
PLATE 7

STRUCTURE MAP

TOP CHECKERBOARD LIMESTONE

CONTOUR INTERVAL 50 FEET

K.L. MISH M.S. THESIS 1989



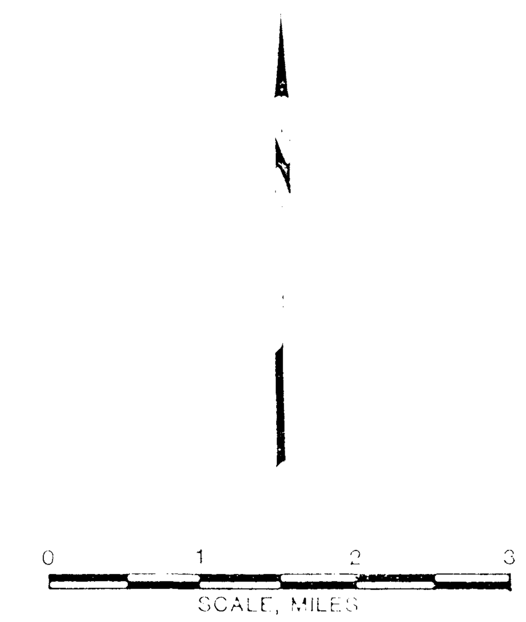


PLATE 8

STRUCTURE MAP

TOP "TRUE" LAYTON SANDSTONE

CONTOUR INTERVAL 50 FEET

K.L. MISH THESIS 1989

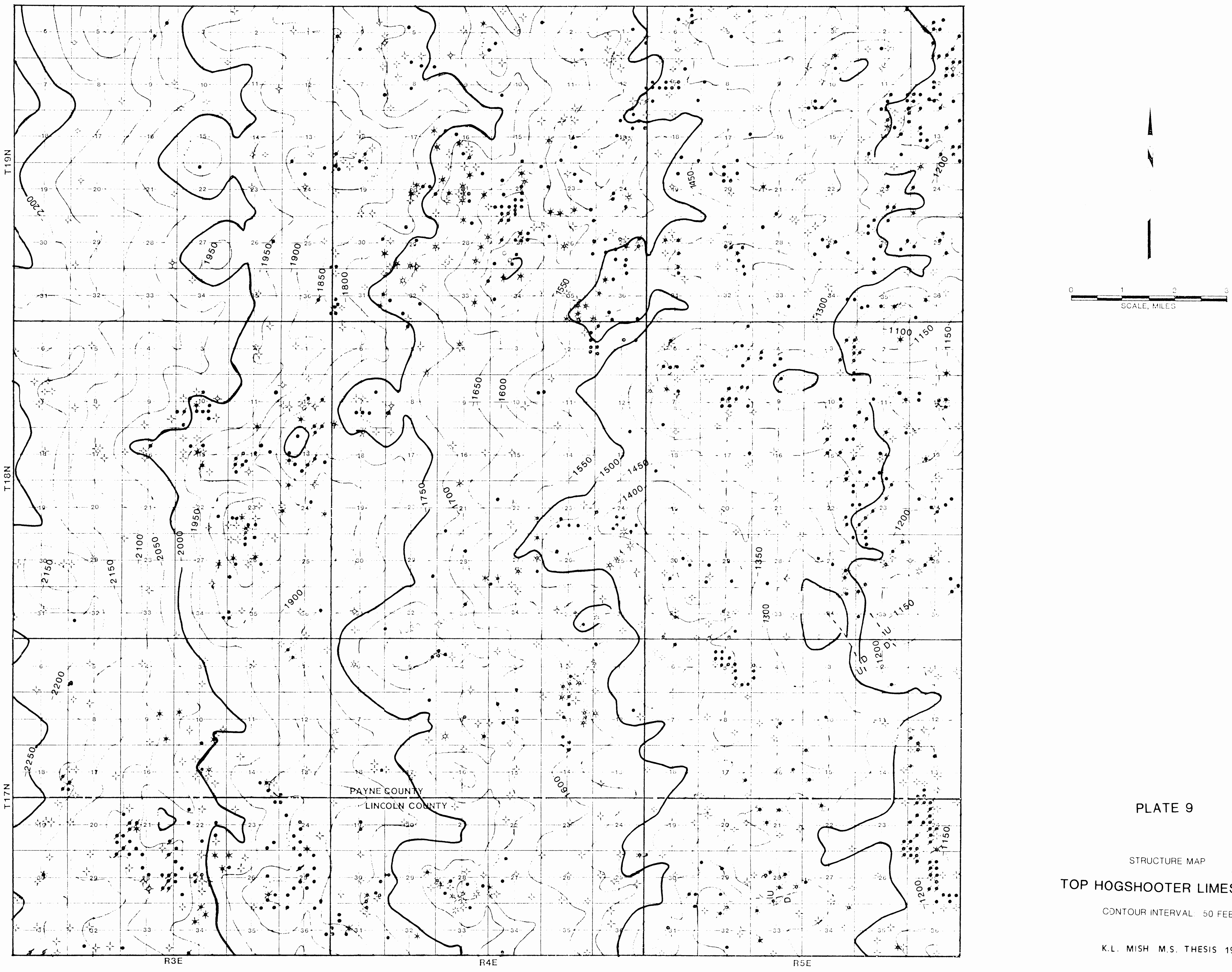


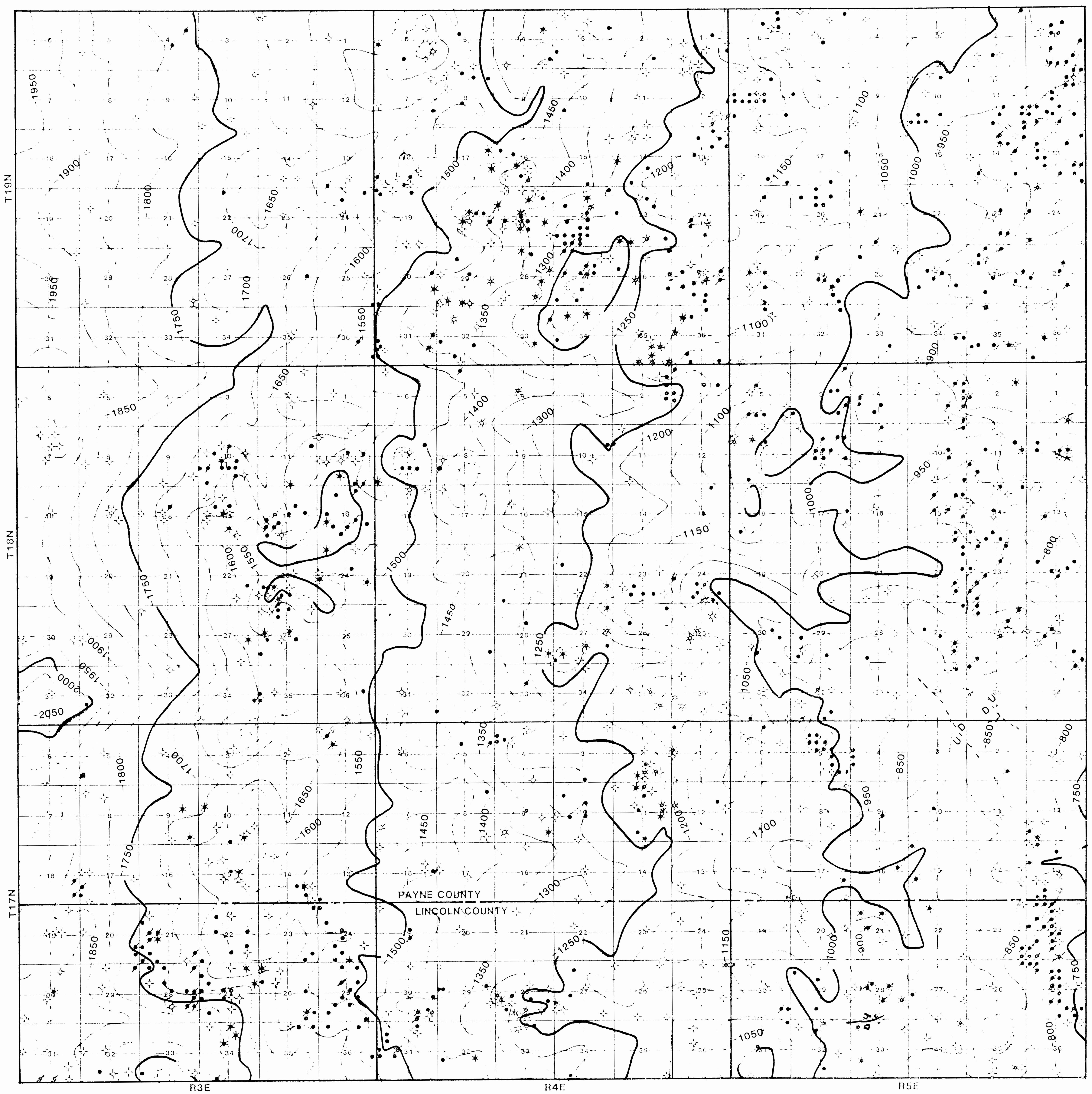
PLATE 9

STRUCTURE MAP

TOP HOGSHOOTER LIMESTONE

CONTOUR INTERVAL 50 FEET

K.L. MISH M.S. THESIS 1989



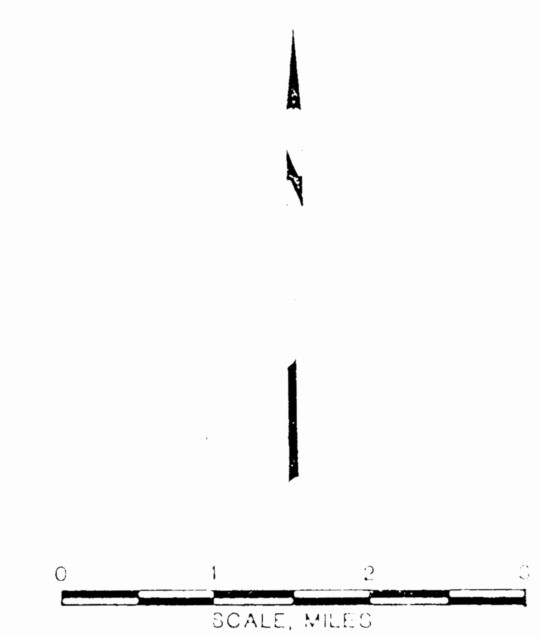


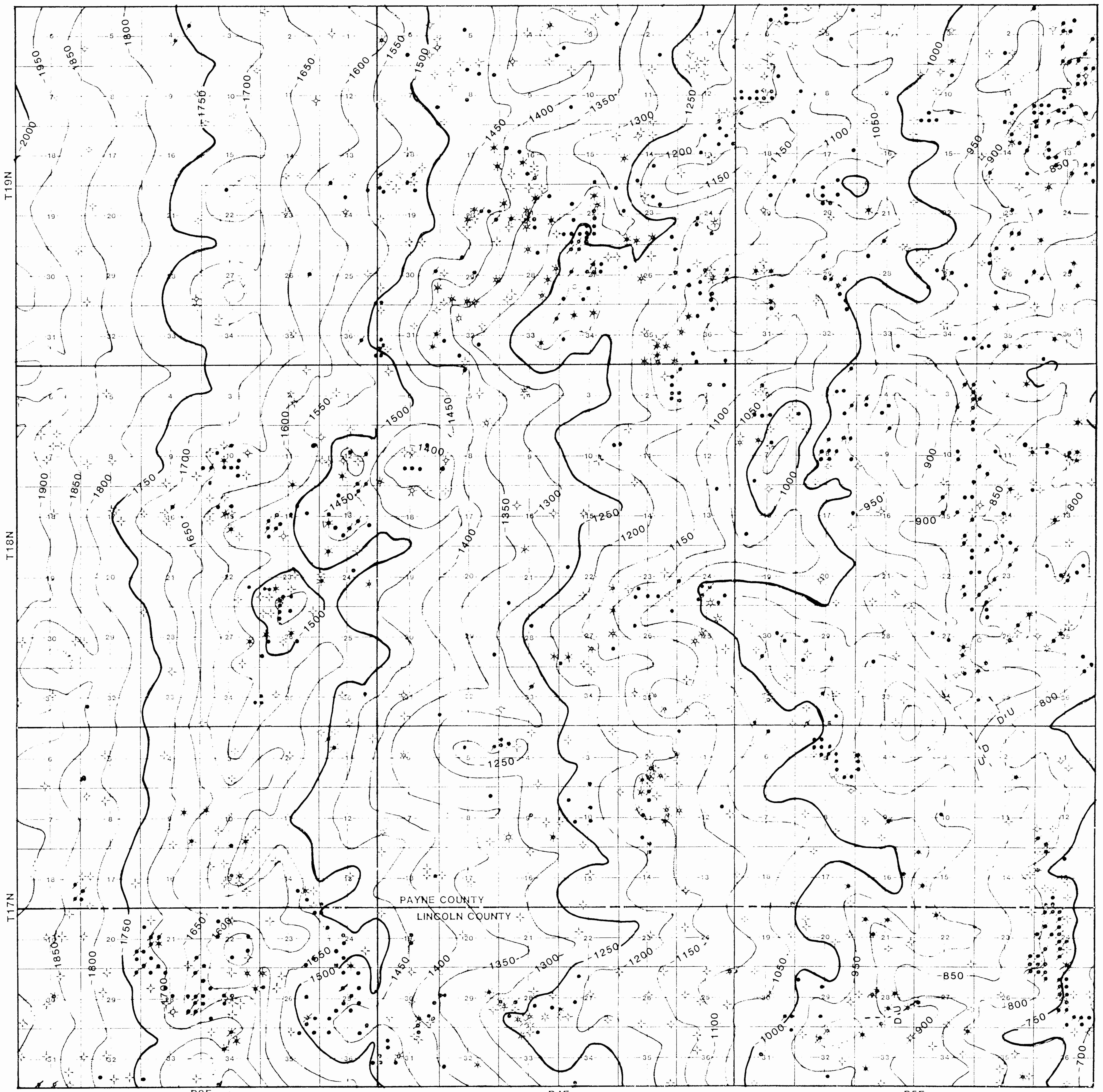
PLATE 10

STRUCTURE MAP

TOP OSAGE-LAYTON SANDSTONE

CONTOUR INTERVAL 50 FEET

K.L. MISH M.S. THESIS 1989



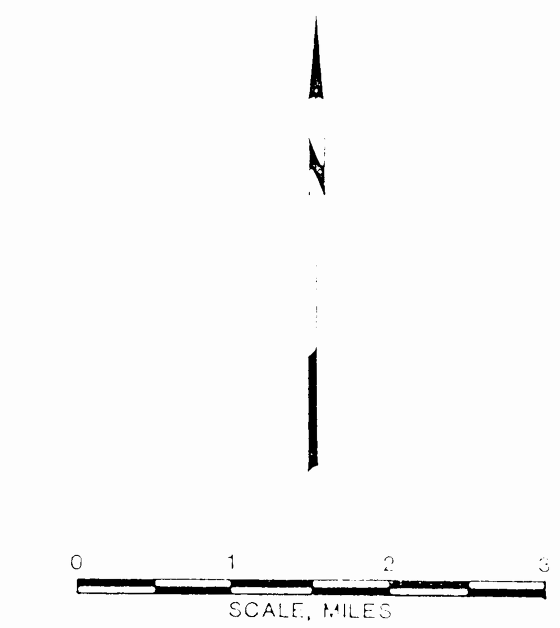


PLATE 11

STRUCTURE MAP

TOP LOULA LIMESTONE

CONTOUR INTERVAL 50 FEET

K.L. MISH M.S. THESIS 1989

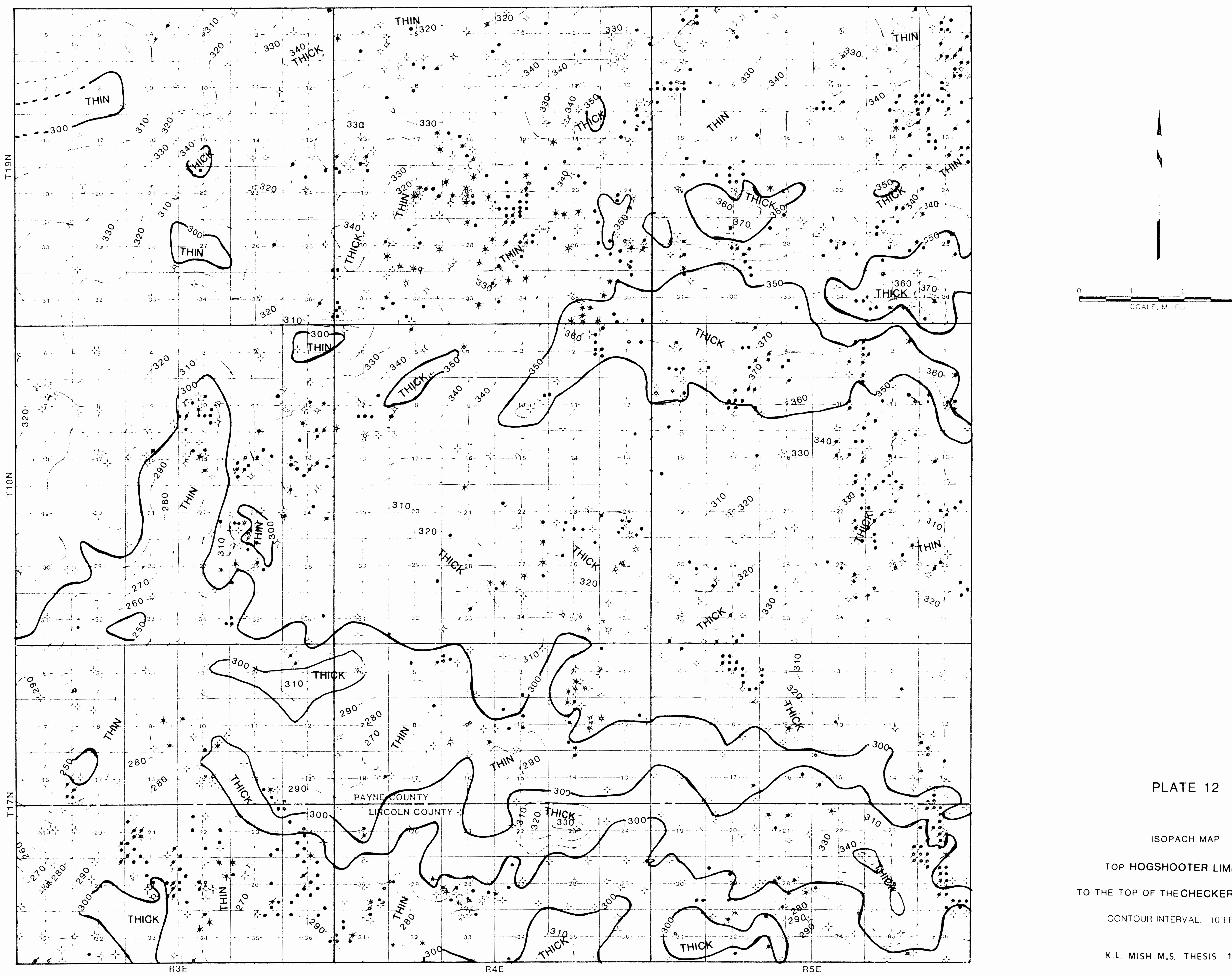


PLATE 12

ISOPACH MAP

TOP HOGSHOOTER LIMESTONE

TO THE TOP OF THE CHECKERBOARD LIMESTONE

CONTOUR INTERVAL: 10 FEET

K.L. MISH M.S. THESIS 1989

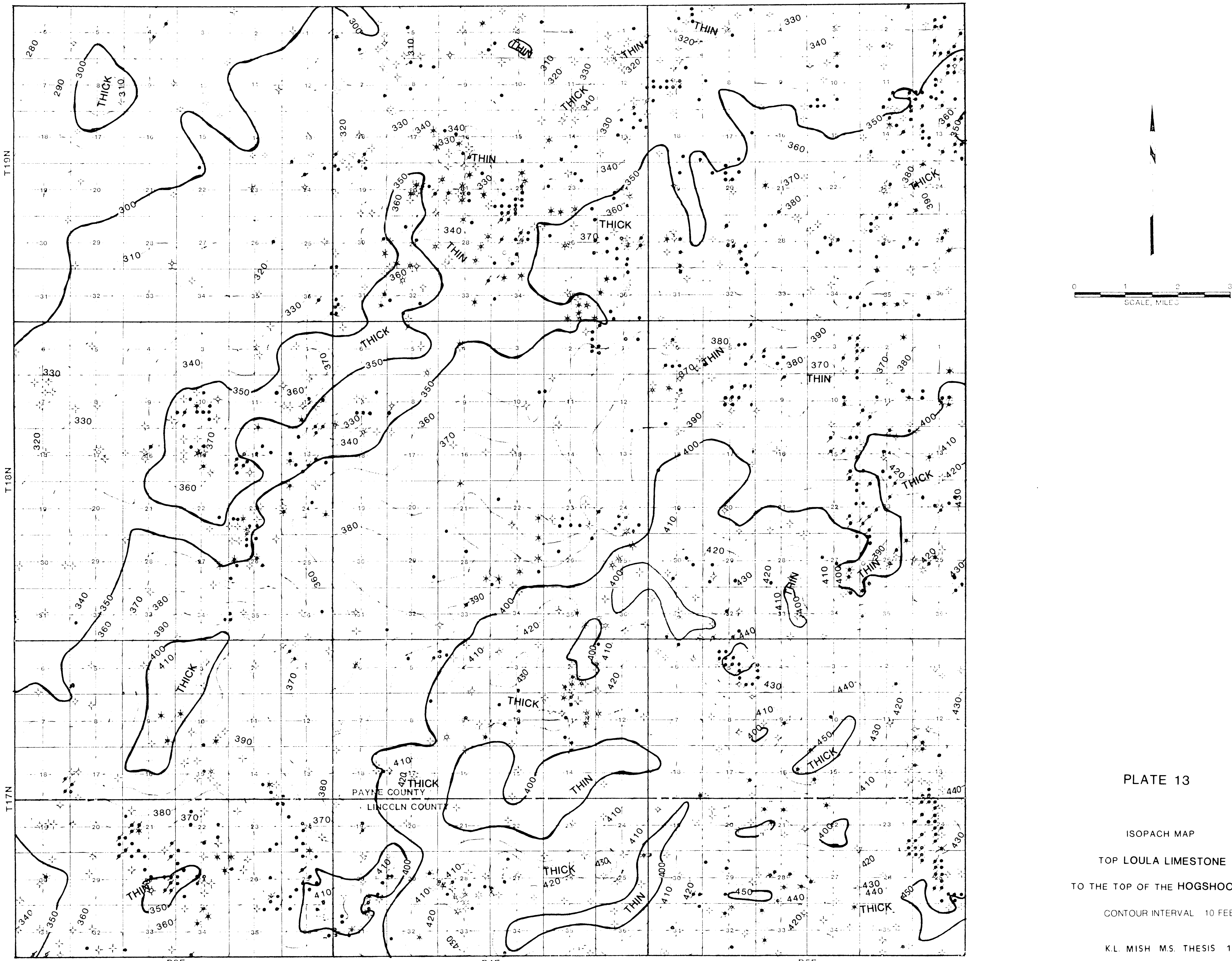


PLATE 13

ISOPACH MAP

TOP LOULA LIMESTONE

TO THE TOP OF THE HOGSHOOTER LIMESTONE

CONTOUR INTERVAL 10 FEET

K.L. MISH M.S. THESIS 1989

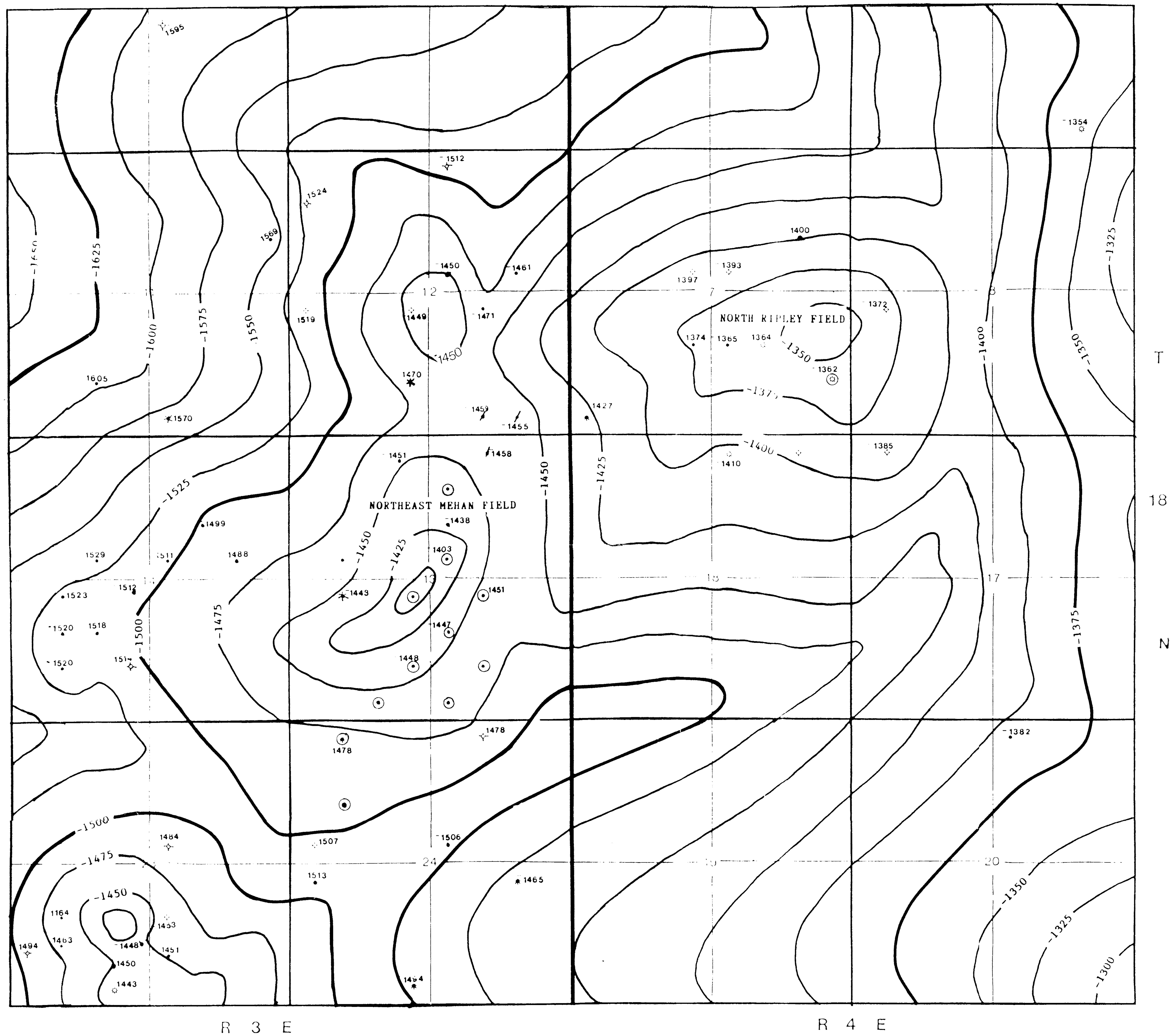


PLATE 14

STRUCTURE MAP

TOP LOULA LIMESTONE

CONTOUR INTERVAL : 25 FEET

K.L. MISH M.S. THESIS 1989